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ABSTRACT

This final report describes a project which developed and examined an instructional paradigm and instructional materials for teaching vocational and prevocational curriculum-based concepts to special needs students. The literature is reviewed concerning student characteristics, the learning situation, and concept characteristics as they affect learning. Research studies on concept learning by the mentally retarded are also reviewed. Several models for teaching concepts are described and the findings of several studies dealing with specific strategies for improvement of concept teaching are summarized. The experimental procedures for the series of substudies conducted by the project are described, which included development of the instructional lesson; development of the instructional materials--line and detailed drawings, photographs, transparencies, photograms, objects, programmed booklets, and audio scripts; development of the dependent measure; selection of the participating schools; and the research designs for the five substudies. Findings are reported as performance differences among four student groups and as effects on learning of speech rates, technical terms, various visual presentation modes, group size, pupil-teacher rapport, and individualized versus group instruction considering the student characteristics of sex, group, reading and math ability, vocational interest, spatial relationship and form perception ability, and finger dexterity. (NJ)

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PROCEDURES FOR TEACHING VOCATIONAL CONCEPTS TO SPECIAL NEEDS STUDENTS

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Final Report of Project #62350274

Development and Examination of an Instructional Paradigm and Auto-Instructional Materials for Teaching Vocational and Pre-Vocational Curriculum-Based Concepts to Mildly Retarded, Borderline Intelligence, and Educationally Disadvantaged Students

Funded in part by the

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— FOREWORD —

Students are the most important ingredient in vocational education, and teaching students in an efficient manner should be one of the most important concerns of vocational teachers, administrators, and support staff. The research reported in this document is intended to provide useful information on an effective approach for teaching vocational concepts to students with special learning needs. Although there is considerable emphasis in the report on the teaching of disadvantaged and handicapped persons, the concept teaching strategies expounded here apply equally to the instruction of all vocational students.

For practical reasons, this report has been condensed to the point where it can be of the most use to practitioners in the field--both teachers and researchers. Individuals who desire more extensive information generated by this particular research project are invited to consult the doctoral dissertations of Barry (1976), Goodwin (1976), and Hull (1976), (see the Bibliography).

Certain parts of this report focus on information that will be of practical value to vocational teachers and supervisors, and other parts focus on information of interest to educational researchers. To direct the attention of the reader to information of importance to classroom teachers, look for this symbol ☆ . It is the sincere desire of the research team which conducted the various sub-studies discussed in this final report that the vocational students of the State of Texas will be the ultimate and the predominant beneficiaries of the project.

Marc E. Hull
Principal Investigator

— ACKNOWLEDGEMENTS —

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The project staff is also deeply indebted to the administrators in the following school districts:

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   Rush Mortimer
   Director of Special Education

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3. Corsicana Independent School District

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Superintendent

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Director of Special Education

4. Houston Independent School District

Billy Reagan
Superintendent

Tom McGee
Director of the Learning Skills Center and the Vocational Skills Center

Pat Shell
Deputy Superintendent for Special Education

5. Klein Independent School District

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Foremost among those who deserve a word of thanks for the success of this project are the 500 students who took part in the study. It is hoped that their involvement in this study will ultimately improve the learning of concepts by many students in vocational education.

Finally, the project staff would like to pay a special tribute to an individual who has played a key role in implementing vocational programs in Texas for students with special needs, Joe B. Neely. Many successfully employed adults are indebted (as are we) to the tireless efforts on behalf of vocational education by Mr. Neely, Director of the Division of Occupational Research and Development, Texas Education Agency. Joe is keenly interested in the welfare of all participants in vocational education (as is his very capable and amiable assistant, Ray Barber). Both of these leaders desire the vocational research that is conducted in Texas to have practical application. This, too, has been our desire, and we will gladly discuss our findings and their application with all those who wish to communicate further with us.

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☆CHAPTER 1: WHAT IS A CONCEPT?

When trying to define what a concept is, we immediately face a dilemma. This is to say that the term "concept" is itself an abstraction, and abstractions are the most difficult concepts to define and to convey. Nevertheless, for purposes of this report we will define a concept (with assistance from Klausmeier and Ripple, 1971) as: a mental construct or image existing in an individual's mind, not in the external world,

> . . . . characterized by psychological meaningfulness, structure, and transferability that enables an individual to do the following: (1) cognize things and events as belonging to the same class and as different from things and events belonging to other classes; (2) cognize other related supra-ordinate, coordinate, and subordinate concepts in a hierarchy; (3) acquire principles and solve problems involving the concept; (4) learn other concepts of the same difficulty level in less time. (p. 402)

To the individual who is not a psychology buff, this definition may seem like alot of meaningless words; but with further explanation it should make sense. First, the definition says that a concept is a mental abstraction, representation, impression, or image which exists in an individual's mind or in the eyes of the beholder, if you will, rather than in the world of concrete things. This is why we can say that: "John's concept of what a diamond in the rough looks like is different from Sally's." or "Eloise and I certainly have different concepts of what work is." Because concepts exist in the mind, they can be thought of as the mental photographs of things seen, heard, felt, tasted, and smelled. Concepts are also the mental constructs by which we deal with abstractions, ideas, and other non-sensed entities.

Concepts can be simple, for example, the mental images we have for such objects as:

automobile	motor	carburator
fuel jet	butterfly	valve

On the other hand, concepts can be complex, for example, the mental images we have for such processes as:

photosynthesis	internal combustion
reforestation	hydraulics

Concepts can be concrete--

open end wrench	ball pein hammer	saber tooth saw

Or they can be abstract--

justice	freedom	values

Concepts can be general (fastener), specific (flat head wood screw), and even more specific (¼" by 1½" brass standard flat head wood screw). Concepts can be supra-ordinate (living things); coordinate (birds, fish, mammals) and subordinate (chestnut-sided warbler, speckled trout, and white tailed deer).

The basis for all concept teaching lies in the fact that concepts have certain attributes which account in large measure for the ease or the difficulty with which they can be learned. Klausmeier, Ghatala, and Frayer at the Center for Studies in Cognitive Learning at the University of Wisconsin (Madison) discuss these attributes at length in their recent publication: *Conceptual Learning Theory* (1974, Academic Press). Included among the attributes of all standardized attributes are:

1. Learnability: the relative ease with which a concept is learned (this can be determined for particular populations through the use of instance probability analyses to be discussed later in the report).

2. Useability: the application that can be made of a concept in problem-solving, in the formation of additional concepts, and in reducing the complexity of an environment.

3. Validity: the extent to which the experts agree on the definition of a particular concept.

4. Generality: the number of subclasses and subordinate concepts which a concept encompasses.

5. Power: the extent to which a concept facilitates the acquisition of additional concepts.

6. Structure: the rule by which the attributes of a concept are related to each other.

7. Perceptibility: the extent to which a concept can be sensed.

8. Numerousness: the relative number of instances of a concept that can be observed or imagined.

The important thing to recognize is that concepts can be communicated and as such are the essential building blocks of human learning. For this reason, each individual's conceptual world is constantly changing and ever expanding. And teachers have, as their primary role in educating individuals, the task of conveying concepts--concepts of all kinds: concrete, abstract, general, specific, supra-ordinate, coordinate, subordiante, and "what all."

To assist the reader to understand the concepts presented in this final report, certain words will be defined in terms of their use in subsequent chapters of the report.

Concept Formation: According to Clark (1975), concept formation is the ability to correctly:

1. Identify the critical, semi-critical and noncritical properties of a concept.
2. Sort out or identify new instances and discriminators of a concept that are presented by the teacher.

3. Find new instances of the concept without help from the teacher. (p. 58)

Positive Instance: A stimulus item which exhibits all the critical properties of a concept in their appropriate relationship is a positive instance. This term is used interchangeably in the literature with the terms "example" and "exemplar."

Negative Instance: A unit which according to Clark (1971) either contains or displays "(a) none or some but not all of the critical properties of a concept in their appropriate or inappropriate relationship, or (b) all the critical properties of a concept but in an inappropriate relationship" (p. 261).

Irrelevant Attribute: A property of any particular example which according to Markle and Tiemann (1969) can be varied without changing the example to a nonexample.

Relevant Attribute: Relevant attributes are those characteristics which according to Woolley and Tennyson (1972) are essential to the item for it to be classified as belonging to the concept. This term is used interchageably in the literature with the terms "essential characteristic" and "critical property."

Value: Qualities which according to Arnone (1971) are the variations that a particular attribute may undergo.

Educable Mentally Retarded (EMR): A widely accepted definition of this term does not exist. Although the term is used frequently in educational settings, the term "mildly retarded" is more commonly encountered outside the field of education. Individual states are expected by USOE to determine the criteria for classifying students by handicapping conditions. In the Administrative Guide and Handbook for Special Education (1973), the

Texas Education Agency defines "children who are educable mentally retarded" as "those who reveal a reduced rate of intellectual development and level of academic achievement below that of their peer age group as evidenced by significant deficits in all essential learning processes" (p. 4). Robinson and Robinson (1965), the authors of an oft-cited textbook definition of the term educable mentally retarded, describe EMR's as individuals whose IQ's fall in the range of 50 to 75 and whose general academic achievement is expected to be between the third and sixth grade level by late adolescence. For this study, the TEA definition rather than the more traditional definition of Robinson and Robinson will be used.

Special Needs Students: The Publications Committee of the American Vocational Association (1976) has tentatively defined special needs students as "those persons who meet the criteria as handicapped or disadvantaged persons who require special programs, modification of programs, or supplemental services to help them succeed in a vocational education program" (p. 43).

Disadvantaged Person: That person who is unable to meet the criteria to enter into, or is unable to progress in or to complete a vocational education program because of: academic underachievement; difficulties with the English language; socioeconomic and cultural background which impinges negatively on that person's motivation, attitude, and lack of knowledge of the world of work; and who, therefore, requires a supplemental program, modification of a regular program, or a special service to succeed in a vocational education program.

CHAPTER 2: VARIABLES AFFECTING CONCEPT LEARNING

★ In one sense, vocational teachers occupy a unique position in the traditional K-12 education continuum. From the standpoint of many students in vocational education, the vocational teacher stands at the far end of the line, which is to imply that what the student learns in vocational education is the capstone of eleven or twelve years of public education. Of greater significance, however, is the fact that what the student learns in vocational education will determine in large measure both the type of job he or she will be able to obtain after exiting education and the level of sophistication with which he or she will be able to perform on a job. Thus, the effectiveness of the vocational teacher in conveying the fundamental skills and concepts of a particular trade and the proficiency of the student in learning the basic skills and concepts of a trade are of great importance.

★ In general education (referring to nonvocational education) it appears that most students survive the system regardless of the type of teaching which they are exposed to from teacher to teacher, year to year, and class to class. In vocational education, by way of contrast, the ultimate criterion of success in a course of study is performance on a job rather than grades received for in-school performance. Thus, in many ways, being successful in vocational education is even more critical than being successful in general education (with the exception of the fundamental skills such as reading, writing, and arithmetic). To teach vocational concepts so that students will successfully learn them, a teacher must be aware of the variables that influence concept learning and, furthermore, be able to manipulate the variables as a part of the teaching act.

Variables that Affect Concept Learning

★Previous research has made it evident that there are many variables which influence concept formation, a fraction of which are shown in Figure 1.

Figure 1

Variables Influencing Concept Learning

Variable Category	Specific Dimensions
Characteristics of the Student	Age, IQ, SES, Personality Traits, Motivational State, Ambition, Self-concept, Preoccupations, Cognitive Style, Prior Achievement
Characteristics of the Learning Situation	Presentation Mode, Reinforcement Schedule, Feedback, Group Size, Labels, Extent of Exposure to Stimulus Items, Pretraining, Practice, Shaping Schedule
Characteristics of the Concept to be Learned	Numerousness and Perceptibility of Instances, Concept Rule, Type of Instance, Concept Dimensions, Relevancy and Dominance of Attributes

Concept learning is a complex phenomenon. Even in carefully controlled laboratory settings it is difficult to account for all of the factors that influence the acquisition of concepts. In the typical vocational classroom or laboratory setting, these factors are greatly multiplied and only a small fraction of them can be isolated for careful study. The findings of previous research on the three variable categories identified in Figure 1 are briefly discussed in the following segment of the report.

Characteristics of the Learner

★Other things being equal, the characteristics of the learner will often predetermine the efficiency with which concepts are learned. Hence, unless the characteristics of the learner are taken into account, concept teaching can be very ineffective even when presumably effective teaching strategies are used.

There are several learner characteristics (for example, IQ, socioeconomic states (SES), and age) over which the teacher can exercise virtually no control. For learners of all ages, intelligence has served as an accurate predictor of both intentional and incidental concept formation. Age, like IQ, has also been found to correlate positively with the rate and efficiency of concept learning. These factors, however, cannot be manipulated; therefore, although they may be of theoretical interest, they have only limited practical application for the classroom teacher.

Some traits of the learner affecting concept attainment can be manipulated through training procedures, thus are of practical interest to the classroom teacher. When concepts must be inferred from a set of cues, impulsive students have been noted to require significantly more trials to solution than reflective students. Further, it has been found that low-anxiety students acquire concepts more rapidly than do high-anxiety students. High-imagery students have out performed low-imagery students (matched for sex, age, and IQ) in learning the names of objects. Performance on dimension-preference tasks also has been found to predict rate of acquisition in concept-identification tasks. However, it has been learned that pretraining on nonpreferred dimensions eliminates the preference effect.

Using a bisensory auditory-visual digit-span task, Ingersoll (1970) identified "visual attenders" and "aural attenders." When the preferred dimension was essential to the solution of the task, Ingersoll found that it significantly influenced levels of attainment. Davis and Klausmeier (1970) found that cognitive style also influences concept-identification performance. Individuals whom the authors identified as high-analytic on an embedded figures test solved concept-identification problems with greater ease than did low-analytic subjects. Again, it was learned that pretraining procedures could be used to anul the differences between students who scored high and those who scored low in an embedded figures test.

★It has been repeatedly found that prior achievement is the most accurate predictor of success in concept learning. Unfortunately, there is very little systematic monitoring of educational achievement in most school systems, thus the only reliable method of determining prior learning for a particular student is the administration of pretests for each concept to be covered in a unit of instruction. Eventhough teachers have only limited control over prior achievement, from the standpoint of research in concept learning, it is pointless to try to teach a particular concept to students who have failed to grasp essential prerequisite concepts. For example, students who cannot perform simple computations or make simple measurements cannot be taught to make up a bill of materials without assistance. Unfortunately, many of us are content to provide the hints and cues that enable students to appear to be acquiring certain concepts and skills when in reality the concepts are beyond their grasp. The literature stresses the importance of pretests to determine which students are ready to learn particular concepts and which students need remedial assistance prior to moving on to more complex concepts.

★Awareness of the effects of various learner characteristics on concept learning coupled with a knowledge of the specific strategies for minimizing or maximizing these effects should make it possible for a teacher to improve the overall level of concept attainment in the classroom.

Characteristics of the Learning Situation

Manipulation of the learning environment including, of course, the instructional materials used to convey concepts directly affects concept learning. Considerable research has been done to determine the influence of various factors that can be manipulated in a classroom setting.

★McMurray (1974) has extensively investigated the effect of using a wide variety of examples to illustrate concepts as opposed to the use of a single instance shown a large number of times. In a series of sub-studies, McMurray found that the wider variety of concept instances were superior for "effecting significantly more correct classifications of previously unencountered instances than . . . the narrow variety repeated" (p. 57). McMurray, in citing the significance of her study, made the following observations:

> First the individual classroom teacher who is looking for the most effective manner in which to present a concept would clearly select as wide a variety of instances feasible within available resources and resource materials. Second, if time constraints were such that only a certain number of instances could be presented, presentation of a wider variety of concept instances of EMR students rather than repetition of only a few would be most likely to promote better concept learning. Third, when using a wide variety of concept instances, the teacher would match examples with nonexamples on irrelevant attributes and present them together as matched pairs in order to focus student attention on the only differing and relevant attribute. (p. 68)

In a study of trait-treatment interaction between aptitude and instructional media, Snow and Salomon (1968) found that low-ability students acquired concepts more rapidly and with better recall with live presentations than with passive (film) presentations.

In a study to determine the effect on performance of varying the amount of detail in a pictorial presentation of a simple and a complex concept, Gorman (1973) found a lack of significant differences in performance in a concept acquisition task in relation to the amount of pictorial detail (line drawings versus detailed drawings), presentation strategy (successive presentation of single instances versus simultaneous presentation of multiple instances) and grade level (fifth graders, ninth graders, and fifteenth graders).

Nelson (1972) found that greater visual detail may be needed when ambiguous concepts are undergoing the process of differentiation. As students become more familiar with a concept, Nelson contends that less visual detail may be needed to induce the concept.

In an analysis of eleven studies reported in the literature, Nielson (1970) found seven studies (for tasks which involve recall, recognition, and concept learning) in which pictorial stimuli were superior to verbal stimuli, two studies in which verbal stimuli were superior to visual stimuli and two studies in which no significant differences were noted. Caput (1974) notes, however, that a careful analysis of the findings of such studies suggests that the superior effectiveness of pictorial modes over verbal modes is a function of the concreteness or abstractness of the subject matter. Superiority of the pictorial mode tends to disappear for conveying content which has nonconcrete or action-process characteristics.

Based on a review of previous research, Lewis (1970) concluded that below average students learn concepts better through pictorial presentations and profit more from pictorial multiple-choice test options than from verbal presentations and verbal multiple-choice test options. She concluded further that for complex, complicated concepts the best mode of presentation is a visual demonstration.

A popularly held assumption is that young children learn concepts more effectively from "real" objects which can be manipulated than from pictorial representations of the concepts. Numerous researchers taking this position advocate a liberal use of concrete objects in the teaching of concepts to young children. In a concept acquisition study involving 36 four-year-old subjects, Devore and Stern (1970) found that for boys there were no significant differences in gain scores which favored the use of concrete objects over pictures for teaching the names of common household articles. For girls, however, there were popular assumptions favoring the use of pictures over the use of real objects. In a related study, Etaugh and Van Sickle (1971) found three-dimensional objects were discriminated more readily than two-dimensional photographs of the same objects by kindergarten children. For college students, on the other hand, Fishkin and Pishkin (1970) found no significant differences between the tactual and visual sensory modalities for processing information provided that the stimulus dimensions in the discrimination task could be discriminated both visually and tactually.

Baker and Popham (1965) designed a study in which they presented groups of students enrolled in a teacher preparation program at the University of California with identical sets of instructional materials, with the exception that one set of materials had pictorial embellishments. Posttest data indicated that there were no significant differences for variables associated with achievement. There were, however, significant differences in favor of the embellished version of the materials in an affective rating of the materials by the student users.

Caput (1974) made a study of the comparative effectiveness of four different visual-verbal presentation modes. The four modes--Spoken verbal (S); Printed verbal (Pr); Spoken verbal with printed verbal (SPr); and Spoken verbal with still pictures (SP)--were examined in each of the two experiments in which a randomized posttest-only design was used. As a measure of the dependent variables, Caput used three objective criterion tests to measure three cognitive learning tasks: learning facts, following procedures, and classifying concepts. Following an analysis of the data derived from his study, Caput drew the following conclusions:

> 1. The sound/pictorial mode tended to be the most effective mode for classifying concepts.
> 2. The simultaneous presentation of nonredundant information through both audio and visual channels resulted in higher levels of performance than through either channel alone.
> 3. Providing relevant pictorial cues rather than presenting verbal information alone produced high performance in learning facts and classifying concepts.
> 4. Audio and print forms tended to yield equally effective levels of performance on cognitive learning tasks.
> 5. Pictorially-supplemented presentations produced higher levels of achievement on pictorial tests than did verbal-only presentations. (p. 91)

Several studies have been made to investigate the superiority of the two principal sensory channels (the auditory and the visual channels) used in learning. Superiority of either channel appears to some extent to be task specific, that is, to be related to the nature of the task. Under circumstances of high redundancy, the combined use of both the auditory and the visual channel appears to be superior to either channel alone (Hsia, 1968; Hartman, 1961). Studies which have found visual presentations superior to aural presentations are counterbalanced by studies which have found the superiority associated with the auditory mode. Ann Lewis (1970) notes several advantages and disadvantages of both types of presentation modes:

> 1. For teaching abstract scientific concepts:
>   a. The visual presentation alone is capable of teaching a concept.
>   b. Verbal presentation facilitates a need for knowledge of technical vocabulary; and uses less time.
>   c. A difficult concept is best taught through a visual presentation.
>   d. Transfer is facilitated best between visual and verbal presentation.
>
> 2. With regard to sheer quantity of sensory response, verbal stimuli, because of their less restrictive nature, are superior to visual stimuli.
>
> 3. Pictures are more easily remembered than words due to their more distinctive characteristics.
>
> 4. The efficiency of visual presentations in learning decreases with age.
>
> 5. Certain types of words (verbs) accompanying pictorial presentations are more effective in aiding teaching. (p. 273)

Other findings of importance regarding the arrangement of materials in concept learning have been noted by Razik (1971) and Sanders, DiVesta and Gray (1972). Razik found that concept learning can be impaired by allowing an insufficient amount of time for students to attend to cues presented audiovisually. Sanders, et.al. (1972) found that a presentation strategy in which similar instances were blocked lead to more rapid acquisition than did intermixing the instances.

★Another variable having a significant effect on concept learning and which can usually be manipulated within the classroom is the mode of responding. Rowe (1972) found that verbal responding during a discrimination learning task was superior to nonverbal responding (pushing a button) for college students. In a replication of the study with fourth grade subjects, Rowe again found differences in the direction which favored a verbal over a nonverbal response mode. Lewis (1970) summarizes her findings on the effects of verbalizing in the following manner:

> 1. Verbalizing the correct dimensional value facilitates shifting.
> 2. With very young children, verbalizing the correct response was better than no response.
> 3. With familiar material, overt responses are insignificant in facilitating problem-solving.
> 4. Speaking-first training, as opposed to listening-first training, best facilitates learning.
> 5. While overt verbalization facilitates concept attainment, the explanation for this is unknown. (p. 273)

★Reinforcement of correct responses has been found to increase both the rate of learning concepts and the efficiency of learning them. There appears, however, to be uncertainty in the manner in which reinforcement should be given. Cahoon (1970) found superior results with an intermittent feedback schedule; (that is, giving reinforcement on a random basis) others have found continuous feedback to be superior. Negative reinforcement has been found by some to be superior to positive reinforcement; others have noted the reverse. More (1969) found delayed-feedback to be superior to immediate-feedback. Bucher found that the benefits of reinforcement were diminished when a competing reinforced activity was also available. Smith (1975) made an interesting finding: In a concept learning task the students assigned to a feedback and practice condition did significantly better than students assigned to a practice-only treatment. The effects of providing cues, examples, practice, and feedback were found to be cumulative with the best performance done by the group receiving the combination.

Feedback given during a concept learning task (usually referred to as prompting) has also been shown to facilitate concept attainment (Merrill and Tennyson, 1971). However, Hardman and Drew (1975) found that the greater the reinforcement in a concept learning task the less the rate of incidental learning.

The use of labels in concept learning has also been studied in depth. Providing highly meaningful labels facilitates concept attainment to a greater extent than low meaningful labels. Etaugh and Averill (1971) found that student-produced labels for stimuli in a discrimination learning task were not superior to experimenter-imposed labels--provided the latter were meaningful to the student. Dickerson (1970) found that the learning of distinctive names (labels) for relevant cues in a discrimination problem was superior to the learning of labels for the irrelevant cues.

Although not widely examined, researchers have sought to determine the effects of grouping on concept learning tasks. Klausmeier (1974) found that students in groups inferred concepts in fewer trials than students working individually. Piland and Lemke (1971) found no significant difference in learning efficiency for either homogeneous or heterogeneous grouping conditions. In a later study however, Lemke, Leicht, and Miller

(1974) found that for low-ability students training to induce a particular concept in heterogeneous groups resulted in better transfer performance than did training in homogeneous groups. The authors presumed that the verbalizations of extroverts in the heterogeneous groups facilitated the acquisition of solution strategies for the low-ability students.

Just as feedback influences concept learning so do certain types of preinstructional activity. White, Richards, and Reynolds (1971) found a significant inverse relationship between the number of pretraining problems students received and the number of trials to criterion. Moore, Hauch, Biddle, and Houtz (1973) found that the acquisition of concepts was improved by the imposition of a risk condition--loss of reward for incorrect performances. Weisberg (1970) found that "advance organizers" (introductory lessons on the concepts to be presented) facilitated the learning of concepts. Levie and Dickie (1973) also noted facilitative effects of organizers for directing attention to relevant attributes. Viel (1975) found that a preinstructional explanation of the use of instructional objectives significantly influenced the attainment of concepts. Etaugh and Averill (1971) in a study of the effects of labeling on a discrimination learning task for five- and ten-year-olds found that verbal pretraining did not affect the discrimination learning of either age group. However, it should be noted that the discrimination learning task was too easy to permit optimal demonstration of labeling effects.

Concept Variables

The nature of a concept itself predetermines in part the ease or difficulty in which the concept will be learned. Some concepts can be easily learned from definitions alone, provided the meanings of the definitions are accessible to the student (Anderson and Kulhavy, 1972). Other concepts are more readily learned from combinations of definitions and rational sets of instances (Feldman, 1972). Some concept attainment tasks are facilitated by the use of negative instances, others by the use of positive instances, still others by combinations of positive and negative instances (Tennyson, 1973). Markle and Tiemann (1969) have found that positive instances produce significantly better generalization than negative instances and that negative instances produce significantly better discrimination than positive instances.

Early studies by Hovland and Weiss (1953) and Olson (1963) showed a superiority for the use of all positive instances in teaching certain types of concepts. Later studies by Denney (1973) and Tennyson (1973) showed a superiority for combinations of positive and negative instances (examples and nonexamples). Clark (1975) has found that the more critical attributes a concept has the more discriminators (closely related concepts) it is likely to have, hence the more precise the teaching must be in order to prevent misconceptions. For this reason, Clark distinguishes between negative instances which differ from a concept by only one attribute or dimension and negative instances that differ along several dimensions. The former he calls discriminators and emphasizes the importance of drawing attention to the single attribute on which a concept and its discriminator(s) differ. Houtz, Moore, and Davis (1973) have had similar findings to those of Clark.

Not only does the type of instance influence concept learning, the number and type of attributes of the instance likewise influence concept attainment. A linear increase in the number of instances to solution and performance errors has been reported as a function of increasing numbers of attributes (Granzin, 1975).

Houtz and Moore (1973) found that in a nondimensioned concept learning task, when the relevant attributes remained constant across instances, the most efficient learning occurred when all of the irrelevant attributes changed. When the relevant attribute changed from one instance to the next, as in the case of alternating positive and negative instances series, the most efficient learning occurred when the irrelevant attributes remained constant.

When presenting a definition with conjunctive relationships between the critical attributes, Markle (1975) found that the technique of arranging the critical attributes on separate lines produced better classification than did a linear prose presentation of the same words.

Several studies have found that increasing the number of irrelevant attributes across instances inhibits concept learning because it reduces the capability of students to attend to and utilize the relevant attributes of the stimuli (Scandura and Voorhies, 1971). Similarly Campione and Beaton (1972) have found that the magnitude of transfer from one task to another is in part a function of the similarity of the stimuli.

The research findings discussed thus far apply equally to all students. Because this study focused principally on the concept learning of the mentally handicapped, a brief discussion follows on the outcomes of concept learning studies with the mentally retarded.

Concept Learning by the Mentally Retarded

In the review of specific concept learning studies, it is often difficult to determine a researcher's rationale for involving the mentally retarded. There appears, however, to be two principal reasons for involving them in such studies; one apparent reason is to document the abilities and inabilities of retarded persons to formulate and utilize various kinds of concepts, while a second apparent reason is to determine what strategies best facilitate the learning of concepts by retarded persons. Although the first reason is of theoretical interest to this study, only the second reason is of practical importance. The latter will, therefore, be dealt with to the greater extent. One thing is obvious; mentally retarded persons, for the most part, acquire concepts at a slower rate and with less efficiency than nonretarded persons of the same age and who have been exposed to the same or comparable instructional settings.

Before citing the outcomes of specific studies which compare the learning of concepts by retarded persons to that of others, it should be pointed out that retardation itself is defined in part as a deficiency in verbal learning ability, thus it is not surprising to find that retarded persons generally perform inferior to nonretarded persons in comparative studies of verbal learning. Deficiency in the overall learning of retarded persons has been attributed to numerous factors: (1) motivational deficits (Harter, Brown, and Zigler, 1971); (2) memory deficits (Baumeister, Hawkins, and Holland, 1967); (3) incidental learning deficits (Brown, 1970). In fact, so much attention has been focused on the learning deficits of retarded persons that an entire theoretical approach to the education of retarded persons has resulted. For a description of the deficit-theory approach, see Gold (1975).

When the performance of retarded individuals has been compared to that of controls matched for mental age (MA) and chronological age (CA), it has been found that retarded persons in concept acquisition tasks make the most errors, take the most time, and require the greatest number of trials to criterion (Blum and Martin, 1960; Milgram and Furth, 1963; Brown, 1970; Blount, 1971; Ullman and Routh, 1971; Lobb and Childs, 1973; Miller, 1973; Switzky, 1973; Bower, 1970). It should be noted, however, that the differences in concept learning between retarded and nonretarded persons vary with the complexity of the learning task.

Miller, Hale, and Stevenson (1968) noted that the differences between the performance of retarded subjects and normals (both CA and MA matched) increased as the learning task was increased in verbal complexity. When the concept attainment task has been sufficiently simple the differences noted above tend to diminish to the point of insignificance (Gargiulo, 1974). Unfortunately, only a few of the studies comparing the concept attainment of retarded and nonretarded individuals have noted specific factors which help to explain the observed differences. Zeaman and House (1963) noted that retarded children may experience difficulty in concept learning tasks because of an impaired ability to select out and attend to specific relevant dimensions. Lobb and Childs (1973) observed that retarded individuals were able to utilize verbalization procedures as well as intellectually average subjects, provided the procedures were simple and meaningful to them. Bower (1970) found that EMR's acquired arithmetic concepts less efficiently than nonretarded students but the differences in the efficiency of learning were less for the concrete areas of money, time, and calendar than for the abstract areas of numerical reasoning, work problems, and measurement. Klausmeier and Loughlin (1961) compared arithmetic problem-solving ability across different intellectual levels. Differences in the retention of mathematical concepts were not significantly different across the three groups, but it was noted that retarded individuals were less persistent in attacking problems, more prone to offer incorrect solutions, and less inclined to use a systematic approach in solving problems than were nonretarded subjects.

Despite the consensus concerning the inferior performance of the retarded in concept learning tasks, studies have found that the mentally retarded may perform as well as nonretarded individuals of the same MA as a result of: (1) repeating the task or performing a similar task (Blum and Martin, 1960; Miller, 1973); (2) keeping within the conceptual framework of the retarded subject (Blount, 1971); (3) making the task nonverbal in nature (Milgram and Furth, 1963); (4) giving EMR's the benefit of additional verbal cues (Landau, 1968).

Because retarded persons attain concepts less efficiently than others do, one may expect to find numerous studies which investigate strategies for improving concept learning by retarded persons. Along these lines, McMurray (1974) notes, "Unfortunately, the empirical studies on effective strategies in concept teaching are few, and those with the mentally retarded are virtually nonexistent" (p. 12). It can be assumed that many of the strategies that affect concept learning in a positive way for nonretarded persons will have a similar facilitating effect for retarded persons although it is not a foregone conclusion that the concept formation research with normal children can be applied to EMR populations.

★A review of numerous studies disclosed fewer than 15 strategies that were found to improve concept learning by retarded persons. A summary of the strategies that have been found to improve the learning concepts by retarded persons includes:

1. Providing familiarity with related higher order concepts (Tymchuk, 1973)
2. Providing verbal cues and modeling (Yoder and Forehand, 1974)
3. Providing sufficient practice on the task (Baumeister, et al., 1967)
4. Focusing attention on the relevant aspects of the task (Brown, 1970; Gold, 1973)
5. Encouraging double responding between the stimulus presentation and reinforcement (Wunderlich, 1971)
6. Increasing the number of relevant dimensions (when the task is inferential in nature) (Ullman and Routh, 1971)
7. Providing various forms of verbal and tangible reinforcement (Insalaco, 1970; Harter, Brown, and Zigler, 1971)
8. Providing self-monitoring aids and corrective feedback (Milgram and Furth, 1967)
9. Having the student state the learning objectives (Warner and DeJung, 1969)
10. Increasing the number of exemplars (Tymchuk, 1973).
11. Familiarizing the student with concept names and exemplary words (for tasks which use the same concepts but different exemplars) (Tymchuk, 1973).

Several researchers have sought to determine the effect of auto-instructional methods of teaching on verbal learning tasks with the mentally retarded. A paired-associates study by Vergason (1966) compared a traditional method of presentation to an auto-instructional method of presentation with educable mentally retarded students who ranged in age from 7.0 to 14.6. Although both methods produced good retention rates on an immediate posttest of 20 sight vocabulary words selected from the "Peabody Picture Vocabulary Test" and matched with corresponding pictorial illustrations, there were significant differences favoring the auto-instructional presentation on delayed posttests given at intervals of one, two, four and fourteen months after the treatment. Other studies which favor the use of auto-instructional techniques with retarded persons were noted in a previous section of this review of the literature.

☆ CHAPTER 3: MODELS FOR TEACHING CONCEPTS

Just as concepts differ along several dimensions, so do approaches to teaching concepts. The important thing to remember is that all of the approaches to teaching concepts which have been published in the literature are research-based. Moreover, all of them have certain elements in common, and the differences between them would appear to many to be strictly academic.

The Markle and Tiemann Model

The Markle and Tiemann (1969) model for teaching concepts is cited frequently in the literature. The first step in preparing to teach a concept according to Markle and Tiemann is to determine the critical and irrelevant attributes of the concept to be taught. In each case, the critical attributes consist of all the properties of a concept which every example of the concept must have--to remove a critical attribute would make it a nonexample. The irrelevant (or noncritical) attribute consists of the properties of a particular concept which can be varied without changing it to a nonexample. The process of concept analysis which we have been discussing is illustrated in Figure 2.

Markle and Tiemann suggest that the number of positive examples of a concept that are needed to teach the concept is equal to the number of irrelevant attributes of the concept. Similarly, the number of nonexamples needed to teach a concept is determined by the number of critical attributes of the concept. In the example above there are three irrelevant

Figure 2

Analysis of the Concept
Round Head Machine Screw

Attributes	Critical	Irrelevant	Action Suggested
a) Color (type of metal)		X	Vary the colors (Silver, brass, bronze, color coated)
b) size		X	Vary the lengths, and diameters
c) type of thread		X	Vary coarseness of thread
d) slot in head	X		Show nonexamples (Phillips head)
e) length of threads (2/3 of body)	X		Show nonexamples (Rivet, sheet metal screw)
f) bearing surface (shoulder)	X		Show nonexample (lag screw)
g) pointed base	X		Show nonexample (Flat head cap screw)

attributes: color, size, and type of thread. Examples would be needed to illustrate at least two variations in each of the noncritical attributes. This would require at least two examples which would illustrate two different types of SAE thread ratings. To illustrate the critical attributes, a minimum set of nonexamples would be needed so that a nonexample could be shown for each critical attribute. Again, a single item could illustrate more than one nonessential characteristic. For example, a phillips recessed point screw could be used as a nonexample of the thread length for a standard flat head wood screw and simultaneously used as the nonexample of a straight slot which is characteristic of all standard flat head wood screws.

The Markle and Tiemann approach to concept teaching is more fully explained in their 1969 publication: *Really Understanding Concepts: or in Frumious Pursuit of the Jabberwock*.

The Clark Model for Teaching Concepts

Of the many models for teaching concepts reviewed by the authors of this final report, the most effective model in our opinion is that which has been developed by D. Cecil Clark (1975) and will be discussed at length in a forthcoming book which Clark has tentatively entitled: *Teaching Single Concepts: Procedures Based Upon Experimental Research.* Clark himself makes the claim that his instructional format is "especially helpful in teaching concepts to children at the primary and intermediate levels as well as to slow and educationally retarded learners" (p. II, 1975). There are five principal components in Clark's format for teaching concepts: (1) identification of critical properties, (2) formation of an objective, (3) selection of materials, (4) presentation of the concept, and (5) evaluation of concept formation. Based on this format a lesson outline for teaching the concept the "Standard Flat Head Wood Screw" was developed as presented on pages 30-32.

Lesson Plan for Teaching the Concept "Standard Flat Head Wood Screw"

I. Identification of critical properties

A. Critical properties:
1. A flat head with a straight slot across the diameter
2. A bearing surface that tapers inward toward the body
3. An upper portion of the body (approximately one-third of the body) with no threads
4. A lower portion of the body (approximately two-thirds the length of the body) with threads
5. A pointed base

B. Semi-critical properties: None
(A semi-critical property is a characteristic which some experts consider essential and other experts do not.)

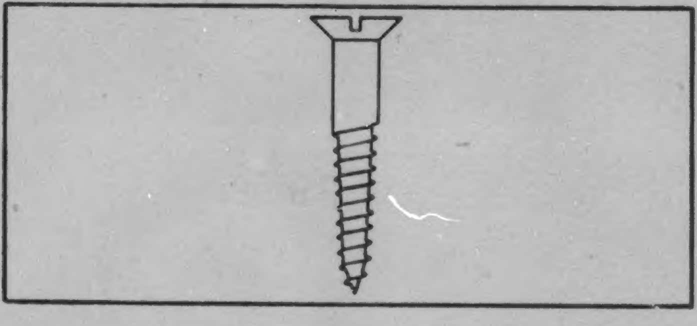
C. Noncritical properties:
1. Type of metal or finish
2. Size of diameter and length
3. Coarseness of threads

II. Formation of an objective

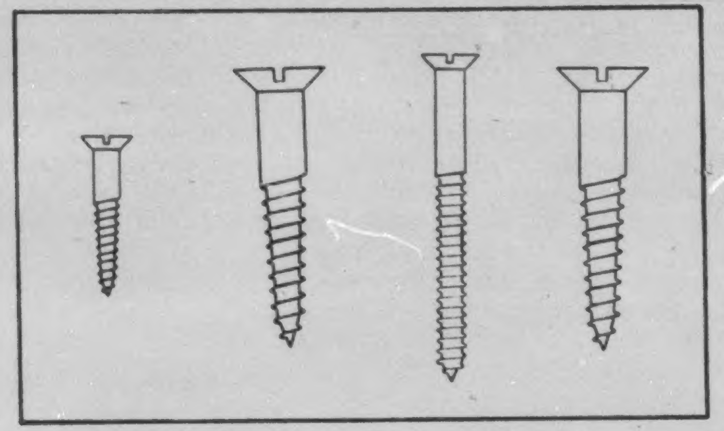
A. Following the completion of a prescribed set of instructional materials, the student will have formed the concept "Standard Flat Head Wood Screw." As evidence of this, he will be able to:
1. Discriminate positive instances of the Standard Flat Head Wood Screw from other types of metal threaded fasteners
2. Distinguish between Standard Flat Head Wood Screws and closely related concepts such as the Flat Head Sheet Metal Screw, the Flat Head Machine Screw, and the Flat Head Cap Screw
3. Generalize across a group of positive instances and discriminators
4. Select new instances of the concept from an array of metal threaded fasteners

III. Selection of materials

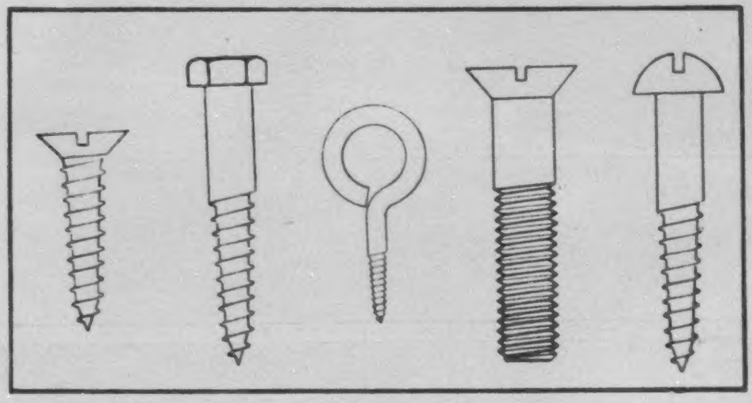
A. Positive instance for formative stage:



B. Positive instances for confirmatory stage:



C. Discriminators for formative and confirmatory stages:



IV. Presentation of the concept

A. In the presentation of the concept, a series of positive examples are shown first and each critical attribute is emphasized. Next an entire array of positive examples is shown and the essential attributes are once again emphasized. This step is followed by comparison between positive instances and closely related nonexamples (sometimes called discriminators). The nonexamples are then reviewed together with a final display of the positive examples and a review of their essential characteristics. (See Appendix A for a set of materials which illustrate each of the steps discussed here.)

V. Evaluation of the concept formation

A. Immediately following the concept formation, the learner is given an opportunity to practice identifying the concept from an array of closely related concepts. This process is often called a formative evaluation phase.

> Immediate feedback is given for each response made. If non-examples are identified as examples, the teacher immediately reviews the materials which cover the item missed--or the teacher takes a new approach to covering the point missed. When the student is able to perform to whatever criterion has been set as evidence of concept mastery, the teaching process is over temporarily. After an appropriate interval, a final evaluation (summative evaluation) is made to determine if the concept can be recalled following a predetermined lapse of time. If the student continues to perform to criterion, the concept is presumed to be mastered--and will in all probability be correctly recalled if intermittent use of the concept is made for an extended period of time.

Other Models Reported in the Literature

In addition to the two models for teaching concepts that have been presented for consideration in this report, there are several others discussed in the literature. Becker, Engelman, and Thomas (1971) developed a model that can be applied to teaching abstract concepts such as mathematical computations as well as applied to teaching concrete concepts. Klausmeier, Ghatala, and Frayer (1974) also discuss several strategies for teaching concepts although they do not espouse a particular model as such. Verduin (1967) presents a design for teaching concepts in *Conceptual Models in Teacher Education, an Approach to Teaching and Learning*. The Verduin model, however, is less practical than either Clark's or Markle and Tiemann's.

For an excellent discussion of a model for teaching mathematics concepts, see the publication of Becker, Engelman, and Thomas entitled, *Teaching: A Course in Psychology*.

The important element of all the models presented here is the *concept analysis*--listing the critical and noncritical (irrelevant) attributes of the concept and selecting or developing examples to illustrate the critical and noncritical attributes.

☆CHAPTER 4: STRATEGIES FOR IMPROVING CONCEPT LEARNING

Several of the studies on concept learning reported in the literature compare one teaching strategy to another. Other studies discuss specifc strategies for improving concept teaching. This chapter will summarize the findings of several of these studies, but a detailed discussion of the strategies is beyond the scope of this report. For additional information, consult the Bibliography.

The superiority of specific strategies has been documented through research activities carried out in both clinical settings and classroom settings. In Figure 3 a summary of the outcomes of studies which have compared one concept teaching strategy to another is presented. The superior strategies are listed in the left column of the figure and the corresponding inferior strategies are listed in the right column.

Effective Strategies for Teaching Concepts

To improve concept teaching, consider using any or all of the following strategies derived from the literature.

1. When presenting concepts for the first time, emphasize their critical properties (attributes or characteristics) and to the extent possible de-emphasize their noncritical properties.
2. When pointing out the critical attributes of a concept, allow students ample time to examine the attributes and encourage the students to repeat aloud the names of the critical attributes.

Figure 3

Superior and Inferior Strategies for Teaching Concepts

Superior Strategies	Inferior Strategies
1. Being told the critical attributes of a concept	1. Discovering the critical attributes of a concept
2. Overt responding (stating critical concept properties out loud)	2. Passive responding (thinking about critical properties only)
3. Live presentations (discussions, demonstrations)	3. Passive presentations (films, printed materials, etc.)
4. Concrete stimuli (pictures, objects, diagrams, etc.	4. Verbal-only stimuli (words--printed or spoken)
5. Listing properties in outlines, tables, enumerations, etc.	5. Listing properties in straight text
6. Positive feedback (points, praise, privileges)	6. Negative feedback (threats, [illegible], demerits)
7. Simultaneous presentation of examples (up to four examples presented together)	7. Successive presentation of examples (examples shown one at a time)
8. Wide variety of examples	8. Narrow variety of examples displayed repeatedly
9. Double responding (stating answer twice)	9. Single responding (stating answer once)
10. Simultaneous presentation of information through audio and visual channels	10. Presentation of information through one sensory channel only

3. Summarize the critical attributes of a concept repeatly during the initial concept presentation and during periodic reveiws at future intervals.

4. Encourage active responding during concept presentations. Move at a stimulating pace but not so rapidly as to loose the attention of the students.
5. Give sufficient feedback to the responses of students. (Both positive and negative feedback influences concept learning.)
6. Use cartoons and visual emphasizers (arrows, pointers, boxes, underlining, etc.) to focus attention on critical attributes.
7. Practice is essential in concept learning. Intermittent (spaced) practice is better than continuous practice that is not repeated at regular intervals.
8. Labeling the critical attributes of a concept facilitates concept learning. Labels should be as clear and simple as possible.
9. The greater the number of pretraining problems presented the greater the ease of concept learning.
10. Under certain conditions, imposing a risk condition (loss of points or other types of rewards) can facilitate concept learning.
11. Concise, clearly stated definitions in conjunction with examples facilitate the learning of concepts.
12. Feedback after both correct and incorrect responses facilitates concept learning.
13. Practice in forming concepts increases the ease with which related concepts are learned.

14. Working in pairs can facilitate the learning of concepts.
15. Simple concepts should be taught before complex concepts.
16. Concepts to be taught should be analyzed to identify their critical and noncritical attributes prior to a presentation of the concepts.
17. Auto-instructional techniques can be effectively used to supplement live concept presentations.

CHAPTER 5: EXPERIMENTAL PROCEDURES FOLLOWED IN THE STUDY

Extensive preparation was required for conducting the series of substudies discussed in this final report. For the individual who may desire to replicate a portion of the study, detailed information may be obtained from the dissertations of Barry (1976), Goodwin (1976), and Hull (1976). The following account of procedures followed in the study is intended to provide sufficient detail to the reader in order for him or her to derive a maximum understanding of the findings of the study rather than to duplicate the study.

Development of the Instructional Lesson

The lesson format developed for this series of sub-studies was based on the Clark (1975) model for teaching concepts. An outline of the lesson format was presented in Chapter 4, and a sample of the instructional materials based on this lesson format can be reviewed in Appendix A.

Prior to developing the instructional materials, the critical attributes of each concept to be presented were identified (see Figure 4).

Development of the Instructional Materials

The development of the instructional materials for the study was carried out over a period of several months. The principal production techniques used in the development of the materials will be briefly described in this segment of the report. In order to carry out the coordination of the visuals with the accompanying audio transcriptions. The

Figure 4

Critical Attributes of Five
Metal Threaded Fasteners

Concept	Head	Bearing Surface	Body	Base
Standard Flat Head Wood Screw	Flat with Straight Slot	Tapers Inward	Top Third Without Threads--Bottom Two-thirds Threaded	Pointed
Round Head Machine Screw	Rounded With Straight Slot or recessed	Forms Right Angle With Body	Completely Threaded	Flat
Fillister Head Cap Screw	Slightly Rounded Head With Straight or Recessed Slot	Forms Right Angle With The Body	Can be Wholly or Partially Threaded	Oval-shaped
Hexagon Socket Set Screw	Hexagon-shaped Cavity Cut Into One End Of The Body	None	Wholly Threaded	Six Standard Shapes
Hexagon Head Bolt	Hexagon-shaped With Straight	Forms Right Angle With The Body	Threaded Up To Two-Thirds of The Body	Flat

preparation of the various visuals is briefly described in the following paragraphs.

Line Drawings

Line drawings ranging in size from 10cm. to 17cm. in length and 2cm. to 4cm. in diameter were drawn with the use of Rapid-O-Graph pens (numbers 00-4) and standard drafting instruments. The original drawings were mounted on a sheet of cardboard measuring 55.88cm. by 76.20cm. and were photographically reduced to 50% and 25% of their original size. From the reductions, ENCO 1250 metal plates were prepared for use on a 1250 multilith offset press in the production of master copies suitable for the development of the instructional materials. When assembled, the master copies were used to print 350 packets of instructional materials using a 1250 multilith offset process (see Appendix A).

Detailed Drawings

Several of the detailed drawings were made by shading in portions of the line drawings with heat resistant Zip-A-Tone. Other detailed drawings were developed from Art-O-Graph projections of the photographs which had been made of the actual objects used in the study. The original drawings were mounted on cardboard and reduced in the same manner as the line drawings. The reductions then were used to make Photographic Mechanical Transfers (PMT's) which, in turn, were used on a 1450 multilith offset press to produce the materials from which the master copies were developed. The master copies were used to print 50 copies of the instructional booklets using a 4250 multilith offset process (see Appendix B).

Photographs

The production of the black and white photographs was carried out by the author of the study and two associates. Standard photographic equipment and accessories were used in the production of the photographs except for a device that was constructed to eliminate distracting shadows. The special device, called a shadowless box, made it possible to photograph the fasteners against a perfectly neutral, shadow-free background. The specifications of the device are given in Appendix C.

To photograph the fasteners, a 35mm. single lense reflex camera using an assortment of attachments was mounted on a copystand adjacent to the shadowless box. Upon completion of the photographing, the negatives were processed according to standard procedures prescribed by the Eastman Kodak Company. A fine-grain developer was used in lieu of a standard developer. The prints were developed with the use of a 4" x 5" enlarger and chlorobromide, polycontrast, single-weight, semi-matte photographic paper. Standard processing steps were followed for the development of the prints.

The original photographs were then cut to appropriate sizes and mounted in frames identical to those developed for the line drawings. When a master copy of all the materials had been assembled, each page of the original materials was again photographed using a standard copystand set-up. The negatives and prints were processed in the same manner as described above with the exception that an ectamatic process was used in the development of the prints. The 8" x 10" photographs were then inserted into vinyl sleeves and put into three-ring notebooks for use by the participants in the study. (See Appendix B for an example of the photographic materials.)

35mm. Color Transparencies (slides)

The color slides were also photographed and processed by the author of the study and his associates. The copystand set-up used was the same as for the photographs. The shadowless box was again used, but in the development of the slides the fasteners were placed on a sheet of clear acetate within inked frames which corresponded in size to the frames developed for the line drawings. Visual emphasizers, identical to those used in the line drawings, and identification numbers and letters were placed on glass frames and shifted for each photograph as needed.

After the photographing, the film was developed according to the procedures prescribed by the Eastman Kodak Company. The processed film was then mounted into 2" x 2" frames and placed into an 80 frame carousel tray.

Photograms

In their simplest form, photograms are shadowgraphs made by placing opaque objects on a sheet of photographic paper, exposing the paper to light, and then developing it in the same manner as photographic prints. Originally, the photograms for use in this study were developed as described above. It was learned, however, that a similar product could be obtained by projecting a 35mm. color transparency onto photographic paper and developing it. Because of the inordinate amount of time required to produce the photograms in the former method, the latter method was used eventhough the product which resulted was not a standard photogram.

The photograms were produced and mounted on black construction paper in a format similar to that of the line drawings. The modified photograms were then photographed using a standard copystand set-up and developed in the same manner as the photographs had been. The 8" x 10" photograms were inserted into vinyl sleeves and put into three-ring notebooks for the use of the participants in the study. (See Appendix B for an example of the photograms.)

Actual Objects

In order to present the actual objects to the students in a manner resembling the presentation of the line drawings and other items, frames suitable for holding the fasteners were constructed from balsa wood. Letters and numbers which served as visual emphasizers were adhered to the balsa frames. The frames were made to be placed in front of the participant as he or she was taught the attributes of one of the concepts in the study.

Overhead Transparencies

Overhead transparencies were made from the original set of line drawings using a standard thermofax process. The transparencies were not mounted.

Programmed Booklets

The programmed booklets were prepared by printing an accompanying script adjacent to each frame on the original set of line drawings (see Appendix B for an example).

Audio Scripts

A script was developed using the technical language of the fastener industry. This script, however, required the use of several terms which, it was thought, would not be a part of the language repertoire of retarded individuals. To determine the effect of the use of technical language in an instructional program, Sub-Study 4 was conceived. It was desired to keep the language of the script as simple and meaningful to the learner as possible, but at the same time to maintain a reasonable degree of technical integrity inasmuch as most tradesmen make exclusive use of the terms of their trades and expect others to use the same technical terminology. (Those who have tried to purchase replacement items for mechanical devices have undoubtedly already found this to be true.) Script I (see Appendix D conformed both to the requirements of Clark's lesson presentation format and to the standard terminology used in industry and technology. Script 2, however, (see Appendix D) substituted analogous terms for the technical terms used in Script 1. All of the terms in Script 2 were believed to be a part of each student's language repertoire (this was later disproved, however).

The audio transcriptions were made by an individual who held a First Class radio announcer's license. The same individual was used to produce all of the transcriptions. To ensure the quality of the recordings they were recorded with the use of a reel-to-reel, semi-professional recording desk (Pioneer Model RT 1050) at 7.5 inches per second on 1.5 mil. Scotch 206 Professional Mastering Tape. A Micho AKG ST-707 Unidirectional Voice Microphone was also used. The reel-to-reel transcriptions were then transferred to cassette tapes for convenience and to make them useable on standard equipment that was available in the classroom

Irrespective of the number of technical words appearing in either script, an effort was made to keep the overall level of communication comprehensible for the students involved in the study. To monitor the level of communication for the two scripts, the Easy Listening Formula (ELF) developed by Irving E. Fang (1966) at the University of California was used. The ELF was designed to measure the average sentence difficulty of television newscasts. The correlation between the ELF and the Flesch Reading Ease Formula was +.96 for 36 television scripts and 36 newspaper samples. Based on an analysis of 152,890 words of text, Fang found that the ELF scores of the most highly rated television news programs averaged around 12. By comparison, an analysis of the technical and the nontechnical scripts used in this study averaged 4.48 and 2.18 respectively. A breakdown by concept of the ELF scores for the two scripts is given in Figure 5.

Development of the Dependent Measure

A test was needed which would assess the ability of the students in the study to (1) correctly select positive instances from an array of related concepts including close-in nonexamples (nonexamples which differ from examples by only one attribute), (2) select nonexamples within both closely matched and divergent pairs, and (3) generalize across groups of positive and negative examples. In addition to meeting the usual criteria of validity, reliability, and useability, the test items were expected to follow certain rules cited in the literature by Markle and Tiemann (1975). "All the examples and nonexamples the student is asked to process will be

Figure 5

Easy Listening Formula
Analysis of Scripts
Used in the Study

CONCEPT	TECHNICAL	NONTECHNICAL
Standard Flat Head Wood Screw	3.14	1.48
Round Head Machine Screw	4.33	1.63
Hexagon Socket Set Screw	5.5	3.23
Fillister Head Cap Screw	5.0	2.18
Hexagon Head Bolt	4.42	2.36
AVERAGE E.L.F. SCORE:	4.48	2.18

new and will bear a predictable relationship to the domain of the concept. Concepts can neither be taught or tested by a single example" (p. 3). To satisfy the latter requirement, the three equivalent test forms were constructed from sets of examples and nonexamples which had been photographically reduced to make them differ in size from the examples and nonexamples used in the instructional materials.

In its final form, the test was comprised of the following items: (1) 30 items which required the students to correctly classify a single positive instance from an array of five related concepts, (2) 10 items which required the students to identify nonexamples when shown a matched pair or a divergent pair of related concepts, (3) five items which required the students to correctly identify all of the positive instances in an array of related instances of which at least two were positive instances.

Face validity of the test was presumed to be high inasmuch as the examples which comprised the test were identical except in size to the items used in the instructional materials. Four instructors with extensive backgrounds in agricultural engineering and industrial education were asked to review the content of the test for accuracy. The only error noted in the test was the identification of a Phillips-recessed flat head wood screw as a standard flat head wood screw. This item was corrected upon verification of the error in a standard reference text.

Content validity was built into the test by the choice of items which were capable of measuring:

1. Overgeneralization--all positive instances plus some noninstances are classified as concept instances.
2. Undergeneralization--not all of the positive instances and some noninstances are classified as concept instances.
3. Misconception--noninstances only are classified as positive concept instances.
4. Concept formation--positive instances only are identified as examples of a concept.

Reliability of the test was first examined by a comparison of the mean scores obtained in a single administration of the test by a group of agricultural engineering undergraduates at Texas A&M University (a group presumably knowledgeable in the content of the test) with the mean scores obtained by a group of EMR students from a local high school. A significant difference between these two groups was obtained; the former group obtained a mean of 67 percentile while the latter group obtained a mean of 30 percentile (a mean which could largely be attributed to the guessing factor). Reliability of the test was further examined by administering it to students enrolled in various vocational education and educational psychology classes at Texas A&M University. A test analysis was made on the basis of how students rated their knowledge of fasteners. The tests were analyzed by the Test Scoring Service of the Data Processing Center at the university. For 26 students rating their knowledge of fasteners as medium or better, the modified Kuder-Richardson (K-R) 20 reliability coefficient was .863; for 25 students rating their knowledge of fasteners as low the modified K-R 20 reliability coefficient was .715. For a group of eight EMR's from Snook Independent School District, the K-R 20 reliability coefficient was .944 following the treatment.

Selection of Schools to Participate in the Study

Specific procedures were followed in securing the participation in the study of students from five independent school districts. In two instances, a formal proposal was submitted to the Superintendent of Schools or his designate. In these districts, the proposal was reviewed and approved by an independent committee of teachers. Approval in both instances was granted based on the potential application of the study to the improvement of classroom teaching. Personal appearances before the Superintendent of Schools were made by the principal investigator of the study prior to conducting the study in the three schools for which formal proposals were not required. At least one orientation meeting was also held with the teachers of students to be involved in the study. Although these pre-study contacts were time-consuming, they had beneficial effects on the subsequent operation of the various studies.

Permission to conduct portions of the study was obtained from the following school districts:

1. Corsicana Independent School District, Corsicana, Texas. (4,600 scholastics)
2. Bryan Independent School District, Bryan, Texas. (8,340 scholastics)
3. Houston Independent School District, Houston, Texas. (212,000 scholastics)
4. Klein Independent School District, North Houston, Texas. (6,000 scholastics)
5. Brenham Independent School District, Brenham, Texas. (3,700 scholastics)
6. Snook Independent School District, Snook, Texas. (500 scholastics)

Selection of Equipment to be Used in the Study

Only a limited amount of equipment was needed to conduct the various sub-studies. A Wollensak Model AV 2551 cassette tape player-recorder and AVID H/88 headsets were used for the audio presentations. A Kodak Ektagraphic slide projector, Model AF-2, was used for the slide presentations. A standard overhead projector was used for the presentation of the transparencies. The projection and audio equipment were arranged in each classroom in a manner which provided for optimum viewing and listening by the students, but at the same time created the least disruption to the customary arrangements within each classroom. The slide presentation was projected against a standard 4' x 5' movie screen.

Research Design for Sub-Study 1

The statistical design for this study contained three independent variables: groups, treatments, and trials, and formed a split-plot factorial design (Kirk, 1972) with 4 x 4 x 4 levels of factors (see Figure 6). The number of students assigned to each of the cells ranged from eight for EMR's to 11 for the CVAE and BT students. The LLD group contained only four persons per cell, so a supplemental analysis was conducted using LLD students from a second school district. Combining the LLD students from the two districts resulted in a mean of nine LLD students per cell, although combining the students was unnecessary for the analysis of the data.

Research Design for Sub-Study 2

Sub-Study 2 consisted of (1) an analysis of sample variance using multiple t-ratios across five visual presentation modes and a control group, (2) an analysis of the differences between specific treatment means using t-ratios, and (3) a series of orthogonol polynomial analyses to determine the presence of trends across successive posttests for five visual presentation modes.

A total of ten randomly selected subjects were randomly assigned to each of five experimental conditions (visual presentation modes) and a control group. This resulted in six cells for the analysis of sample variance as indicated in Figure 7.

Figure 6

EXPERIMENTAL DESIGN

Group	Treatment	Pre-test	Post-test 1	Post-test 2	Post-test 3
EMR	X_1	O_1	O_2	O_3	O_4
	X_2	O_1	O_2	O_3	O_4
	X_3	O_1	O_2	O_3	O_4
	C	O_1	O_2	O_3	O_4
LLD	X_1	O_1	O_2	O_3	O_4
	X_2	O_1	O_2	O_3	O_4
	X_3	O_1	O_2	O_3	O_4
	C	O_1	O_2	O_3	O_4
CVAE	X_1	O_1	O_2	O_3	O_4
	X_2	O_1	O_2	O_3	O_4
	X_3	O_1	O_2	O_3	O_4
	C	O_1	O_2	O_3	O_4
Building Trades Students	X_1	O_1	O_2	O_3	O_4
	X_2	O_1	O_2	O_3	O_4
	X_3	O_1	O_2	O_3	O_4
	C	O_1	O_2	O_3	O_4

Figure 7

Sources of Treatment Variance for Sub-Study 2

Line Drawings	Detailed Drawings	Photograms	Photographs	Colored Slides	Control

Five separate concepts selected from the general concept class, metal threaded fasteners, were presented to the subjects who were assigned to one of the five presentation modes. Prior to and immediately following the treatment, the students were administered a 45-item test to determine the extent to which they were able to correctly discriminate positive instances of the five concepts from noninstances and the extent to which they were able to generalize the specific concepts across classes of related concepts.

All groups were pretested and administered three successive posttests; the first of which was given immediately after the treatment, the second approximately four weeks after the treatment, and the third approximately eight weeks after the treatment. The basic design of Sub-Study 2 is portrayed graphically in Figure 8.

Figure 8

Research Design for Sub-Study 2

Group	Pretest	Treatment	$Post_1$	$Post_2$	$Post_3$
1	0	Line Drawings	0	0	0
2	0	Detailed Drawings	0	0	0
3	0	Photograms	0	0	0
4	0	Photographs	0	0	0
5	0	Colored Slides	0	0	0
6	0	Control	0		

Research Design for Sub-Study 3

Sub-Study 3 consisted of an a priori orthogonal comparison between two visual presentation formats and a control group. Actual objects were used as the visual stimuli for one experimental group, and line drawings of the objects were used as the visual stimuli for a second experimental group. Basically, this experiment was an extension of Sub-Study 2 which originally included actual objects as one of the treatment conditions to be studied. The actual objects were later dropped from Sub-Study 2, however, because unlike the other treatments it introduced the need for one-to-one interaction between the experimenter and the subjects. A separate experiment, therefore, was added to the study.

Because it was found in Sub-Study 2 that line drawings were not significantly different from the other visual modes, this particular mode was arbitrarily selected as an experimental conditions in Sub-Study 3, thus making a comparison between the most abstract visual mode of presentation and the most realistic form of the corresponding concept. Both treatments were administered in a setting which permitted one-to-one interaction between the subjects and the experimenter. A control group was tested across the same material but was given a treatment consisting of instruction in the identification of two hand tools. The basic research design for Sub-Study 3 is portrayed in Figure 9.

Figure 9

Research Design for Sub-Study 3

Group	Pretest	Treatment	Post_1
1	0	Line Drawings	0
2	0	Actual Objects	0
3	0	Control	0

Research Design for Sub-Study 4

Sub-Study 4 featured a comparison between two types of audio transcriptions, the use of technical language versus the use of analogies and words presumed to be in the language repertorie of the subjects. As in Sub-Study 3, two experimental groups and a control group were utilized and multiple posttests were administered so that a trend analysis could be made of the rate of retention for the experimental groups. The research design for Sub-Study 4 is shown in Figure 10.

Figure 10

Research Design for Sub-Study 4

Group	Pretest	Treatment	Post_1	Post_2	Post_3
1	0	Technical Language	0	0	0
2	0	Nontechnical language	0	0	0
3	0	Control	0		

Research Design for Sub-Study 5

Sub-Study 5 used a pretest-posttest design without a control group (see Figure 11).

Figure 11

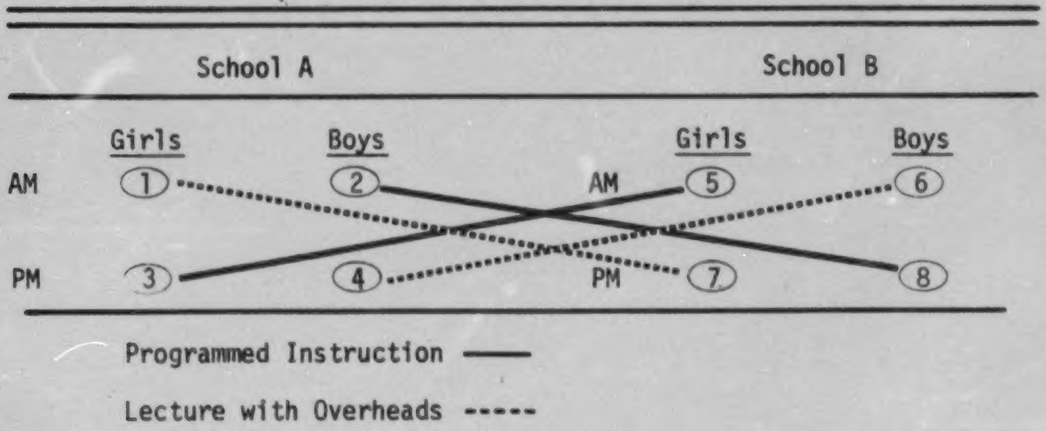
Research Design for Sub-Study 5

Group	Pretest	Treatment	Posttest
1	0	Lecture with Overhead	0
2	0	Programmed Booklets	0

Variance was controlled by assigning classes with similar characteristics to corresponding treatments depicted in Figure 12.

Figure 12

Assignment Strategy for Sub-Study 5


School A
School B
Girls
Boys
Girls
Boys
AM
①
②
AM
⑤
⑥
PM
③
④
PM
⑦
⑧
Programmed Instruction ——
Lecture with Overheads -----

☆CHAPTER 6: FINDINGS OF THE STUDY

In this chapter the findings of the study are presented, but the implications of the findings are not discussed until Chapter 7.

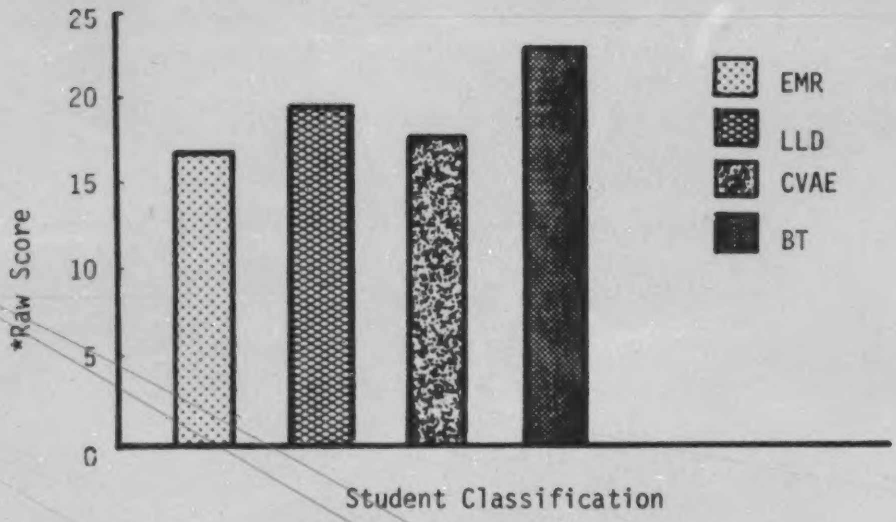
Performance Differences Between Four Student Groups

The first sub-study sought to obtain an accurate comparison of the performance of various groups of vocational students on a concept learning task: EMR students, LLD students, CVAE students, and Building Trades (BT) students. Performance levels were determined for each of the groups by administering a pretest, a treatment, and three successive posttests.

Approximately 150 students were involved in this sub-study, the results of which are shown in Figure 13.

Figure 13

Performance Across Pretest and Three Posttests
by Student Classification



*The maximum possible score was 44

The range of performance fell between a group mean of 23.5 for BT students and a group mean of 16.4 for the EMR students. In an analysis of the raw scores across all tests (including the pretest), it was observed that BT students scored significantly higher than EMR, LLD, and CVAE students as noted in Table 1.

Table 1

Results of the Multiple Comparison Test
for the Main Effect: Student Classification

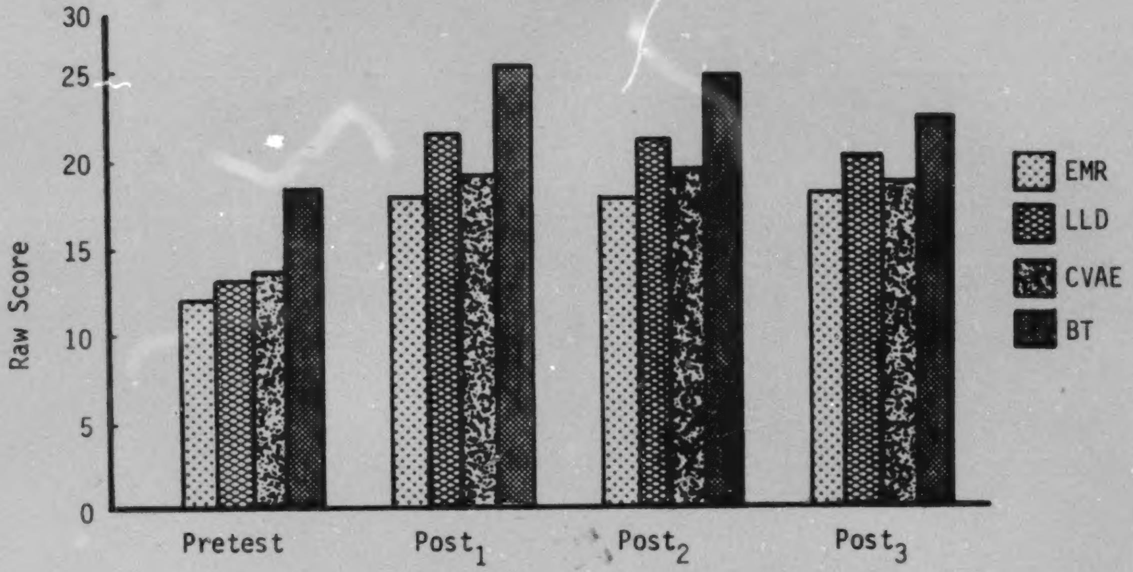
Classification	EMR	LLD	CVAE	BT
Number of Scores Averaged	N = 128	N = 64	N = 192	N = 176
Mean	16.4	19.7	18.0	23.5

To show the consistency of the findings across the four student groups, the performance of each group on the pretest and the posttests is presented in Figure 14.

From Figure 14, it can be observed that the initial performance of the students as measured by the pretest followed a similar pattern on the posttests with the exception that the LLD students outperformed the CVAE

Figure 14

Performance by Student Classification for a Pretest and Three Posttests

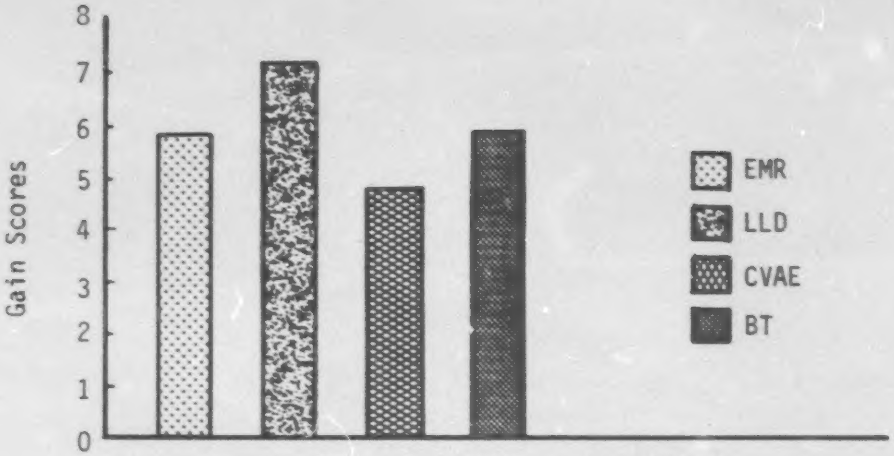


students on the three posttests although their baseline behavior (pretest performance) was inferior to that of the CVAE students.

An analysis of the differences in performance by the various student groups would not be complete without an analysis of the gain scores achieved by the four groups. Gain scores are in many ways a more accurate indicator of learning on a particular task than raw scores alone, because they eliminate in part the advantages given to groups which score high on a pretest but subsequently do not learn as much as groups which score low on the pretest. Gain scores are defined as posttest scores minus pretest scores. The gain scores for all groups across the three posttests are presented in Figure 15.

Figure 15

Gain Scores for All Groups Across
All Posttests



Performance by Student Classification
Across all Trials (3 Posttests)

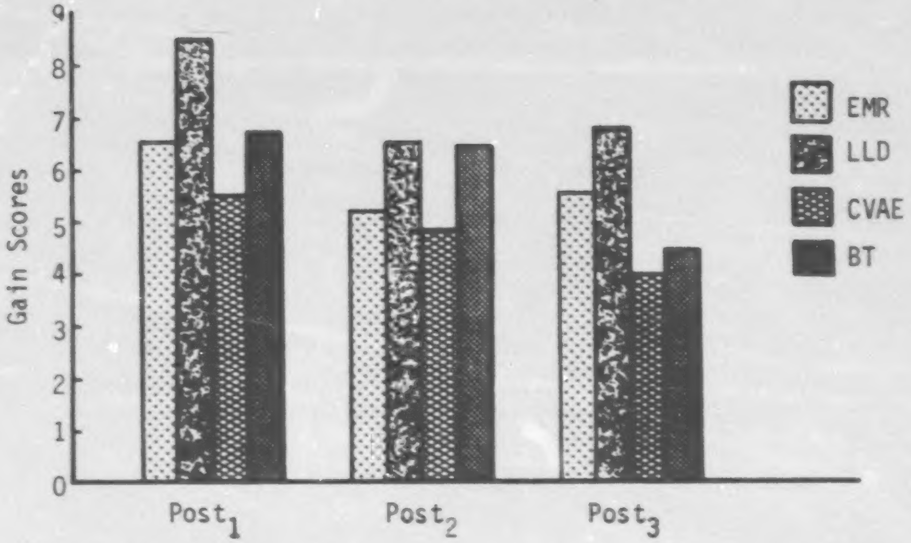
Performance in terms of gain scores was not significantly different across the four groups. Compared to their pretest performances, it can be observed that EMR and LLD students learned proportionately more than the CVAE and the BT students. A breakdown of the performance by groups across the three posttests revealed a similar pattern. Again, it can be seen in Table 5 that the superior learning performance of the LLD students held across each of the posttests. The gain scores for CVAE students were less than the other groups across the three posttests, and EMR and BT students performed about equal to one another. Retention across the three successive posttests did not significantly increase or decrease.

The Effects of Speech Rates on Learning

A second objective in Sub-Study 1 was to determine the effects of time-compressed and time-expanded speech on the learning of concepts.

Figure 16

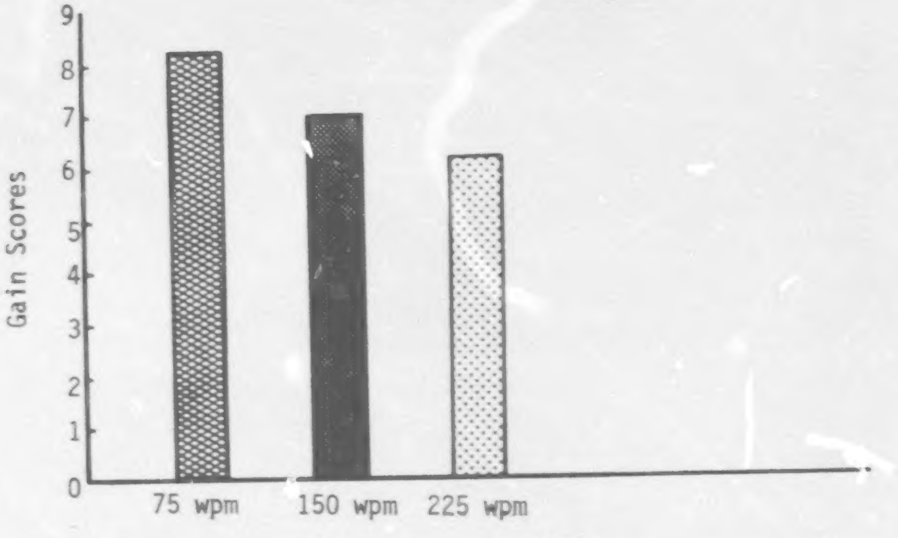
Gain Scores for All Groups
For Three Posttests



For this study, students were given identical visual materials but were assigned to oral presentations at different rates of speed ranging from 75 words per minute (wpm) to 225 wpm. The performance of students assigned to the various speech rates are shown in Figure 17.

Figure 17

Effect of Words Per Minute Across
all Trials and Groups



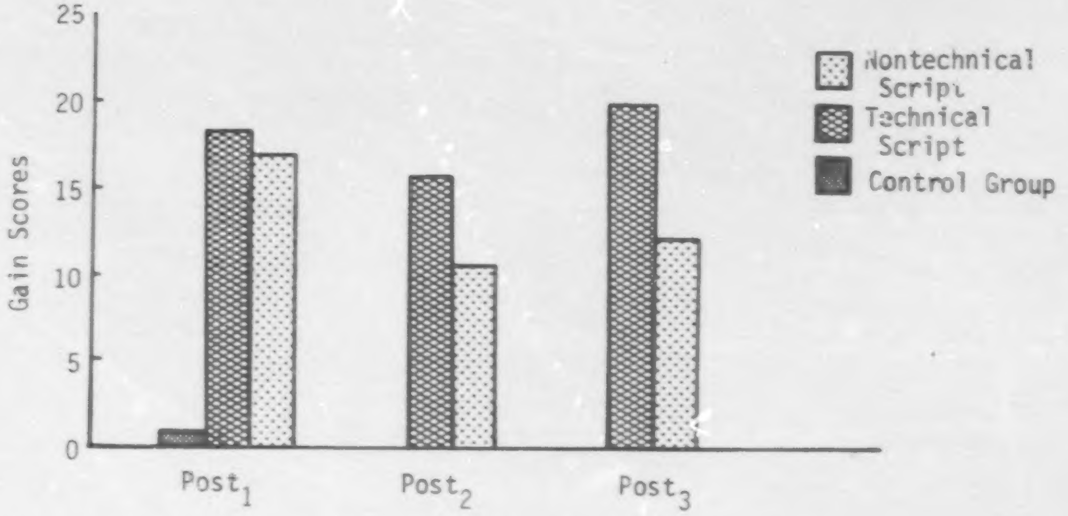
The effects of the rates of speed were not significantly different across the three speeds, the implications of which are discussed at length in Chapter 7. The three rates of speech influenced concept learning similarly for all groups and all trials.

The Effects of Technical Terms on Learning

A second sub-study dealing with oral presentation variables investigated the influence of two levels of technical terminology on the acquisition of concepts by EMR students. Two taped transcriptions were prepared, one with a high level of technical terms, the other with a minimum of technical terms. The gain scores for the two groups plus a matched control group for the first posttest are given in Figure 18.

Figure 18

Gain Scores for Two Levels
of Technical Terminology



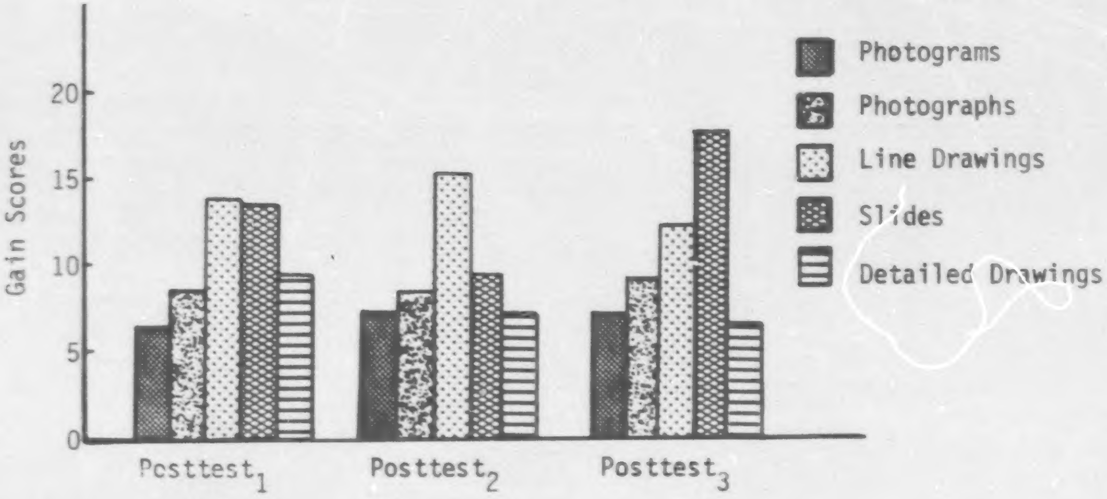
It is readily apparent that the treatment having a large number of technical terms did not adversely affect the performance of students on the three posttests. To the contrary, students receiving the narrative with the technical terms scored higher on each posttest than did students who received the nontechnical script. Both groups performed significantly better than a matched control group. Retention of the concepts across three posttests administered at approximately 30-day intervals did not significantly increase or decrease for either treatment.

The Effects of Various Visual Presentation Modes on Learning

The next series of sub-studies examined the influence on concept learning of six visual presentation modes: (1) line drawings, (2) detailed drawings, (3) photograms, (4) photographs, (5) 35mm. color slides, and (6) actual objects. The first of this series of sub-studies involved five visual modes. The gain scores associated with each visual mode across three posttests are graphed in Figure 19.

Figure 19

Gain Scores for Five Visual Modes
Across Three Posttests

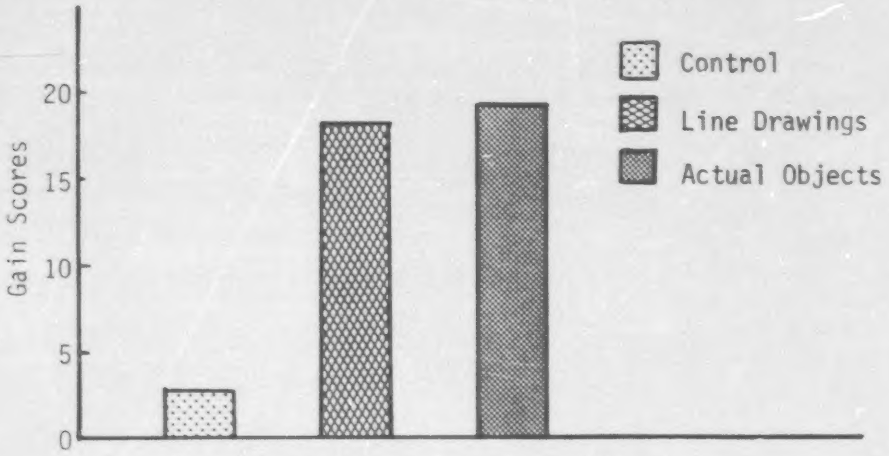


The differences between the groups were not significant at the .05 level (five chances in 100 that the data could have occurred by chance), but they were significant at the .07 level. Thus, it can be said that there were trends favoring line drawings and colored slides as the most effective visual presentation modes for teaching the concepts in this study.

In a related study which investigated the effects on learning of line drawings (the format with the least visual detail) and actual objects (the format with the greatest visual detail). The outcomes of this study are given in Figure 20.

Figure 20

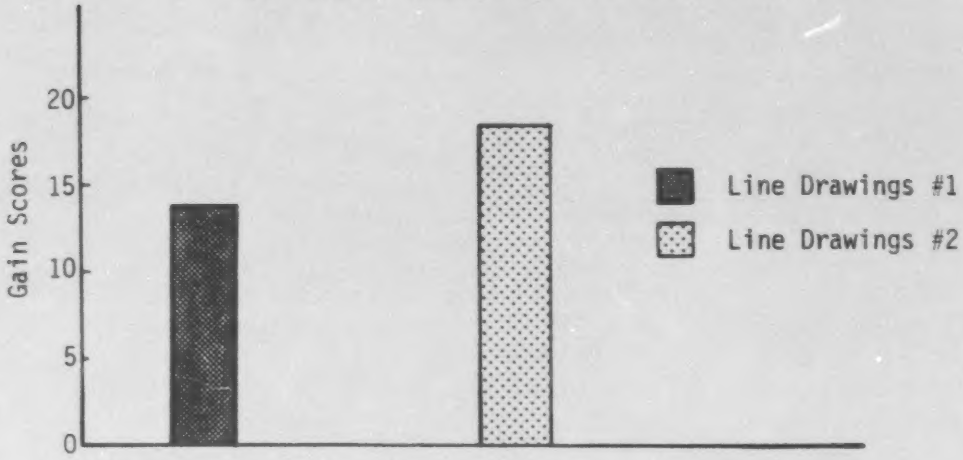
Gain Scores for Two Visual Formats



There were no differences in the gain scores obtained by the participants in this sub-study. It is interesting to note, however, that the performance of students assigned to line drawings in this study was superior to that of the students assigned to line drawings in the previous study as depicted in Figure 21.

Figure 21

Gain Scores Associated with Group Size

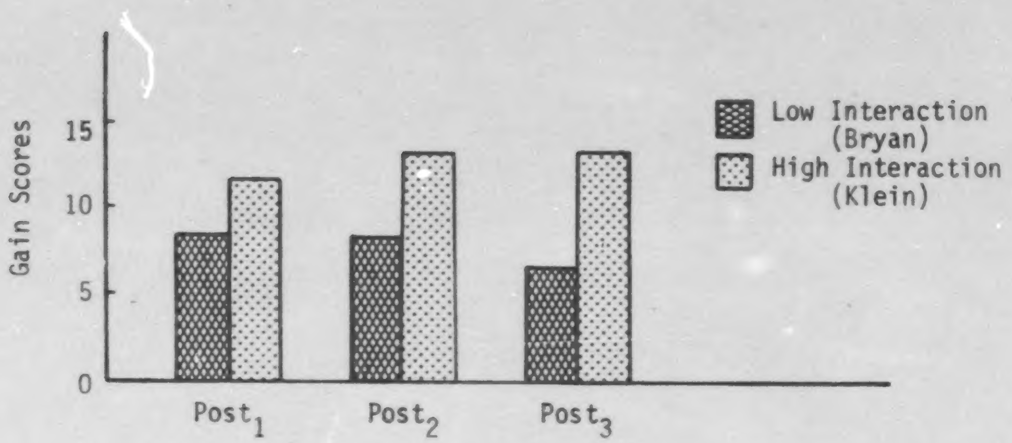


It is assumed that the two groups had equal potential to achieve the higher gain score and that the observed difference was the result of an instructional variable which we presume to be "group size." The students received identical instruction except one treatment was administered to a group of 20 students simultaneously while the other treatment was administered to a maximum of four students per setting, thereby giving the higher scoring group considerably more rapport with the experimenter. A possible explanation for the observed differences is given in Chapter 7.

A second informal analysis was made between a group of LLD students in the Bryan Independent School District and a corresponding group of LLD students in the Klein Independent School District. Both groups received identical instruction except in one instance there was a high degree of interaction between the experimenter and the participants, whereas, in another instance, interaction between the participants and the experimenter was minimal. The achievement in terms of gain scores of the two groups for three posttests is shown in Figure 22.

Figure 22

Gain Scores Associated With Experimenter/Pupil Interaction

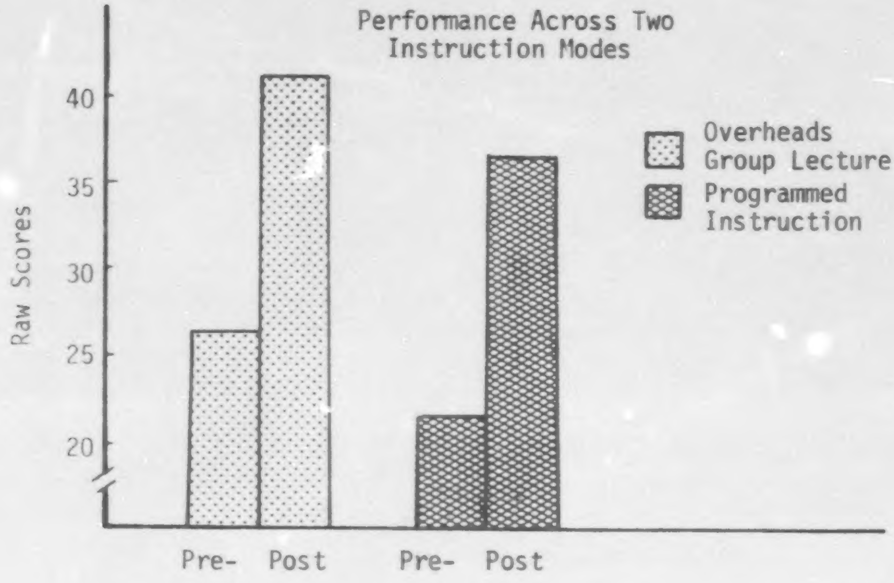


Individualized Instruction Versus Group Instruction

Another sub-study sought to determine the effect on concept learning of two instructional modes, a lecture presentation with overheads versus programmed booklets with a written script. Ninty-two students participated in this sub-study with 46 students assigned to each treatment, the data for which are presented in Figure 23.

Figure 23

Performance Across Two Instruction Modes



The students who participated in this sub-study were administered several additional tests in order to determine the types of interactions which might occur between certain characteristics of the learner and the instructional program to which they were assigned. The means and standard deviations for the various independent measures are presented in Table 2. In addition to the student variables identified in Table 2, the correlation between pretest performance, posttest performance, and gain scores was calculated for ten variables. These data are shown in Table 3.

Table 2

Means and Standard Deviations for Selected Student Traits

Treatment		Characteristics					
		IQ	Read	Arith	Spa. Rela.	Form Perc.	Finger Dexterity
Lecture with Overhead	$\bar{X}$	83.7	6.0	6.3	97.8	96.5	87.2
	SD	10.0	1.2	1.1	24.4	15.1	23.8
Programmed Instruction	$\bar{X}$	80.5	6.2	6.2	98.0	90.5	86.9
	SD	10.9	1.4	1.4	24.2	15.2	17.4

Table 3

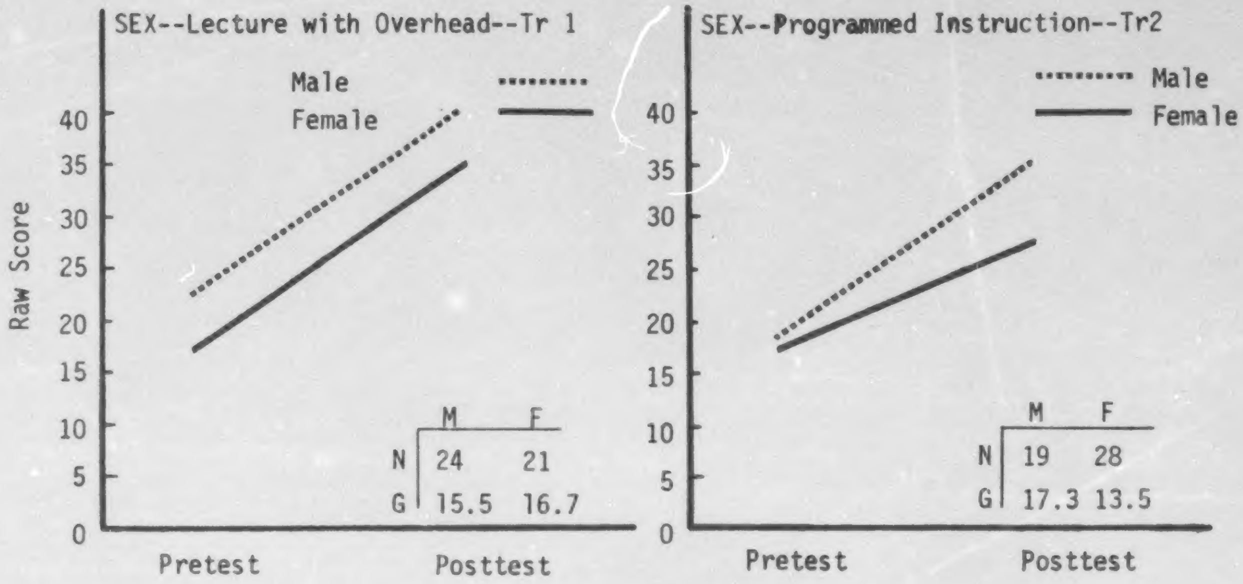
Correlation Between Selected Student Variables and Test Performance

	Pretest	Group	Kuder	S	P	F	Read	Math	IQ	Sex
Gain Score	-.3252	.1475	-.0059	.087	.2711	.0312	.0836	.0926	.0814	-.0631
	Group	Kuder	S	P	F	Read	Math	IQ	Gain	Sex
Pretest	-.3309	.1028	.4281	.057	.1395	.3631	.2892	.4406	.325	.1236
	Group	Kuder	S	P	F	Read	Math	IQ	Gain	Sex
Posttest	-.1679	.1138	.4728	.298	.1155	.3287	.3133	.4619	.495	.8068

Using selected independent measures as the rationale for dividing the students into various subgroups, the effect on learning of particular student characteristics was examined. The outcomes of the analyses associated with this portion of the study are given in the tables that follow. In addition to depicting the pretest and posttest performance for the two treatment, the graphs denote the number of students used in the calculation of the group means and the gain scores for each group.

Figure 24

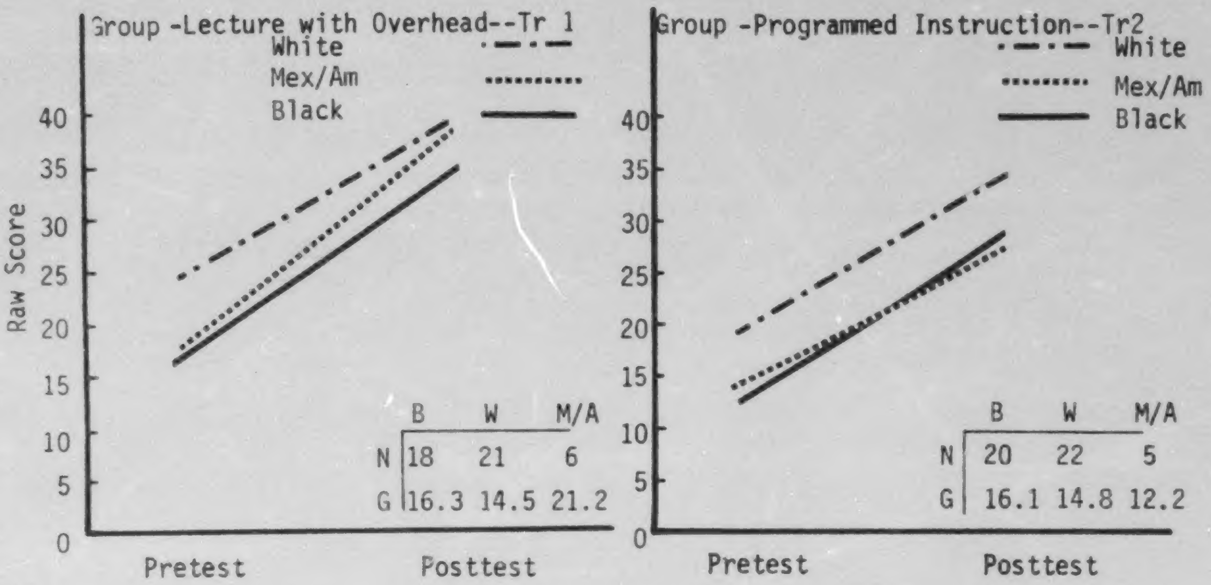
The Relationship Between Sex and Performance
Across Two Instructional Modes



In this study, males scored higher than females on the posttests for both treatments (PI 35.1 and L 38.3 versus PI 28.8 and L 33.8). In terms of gain scores, the females obtained the higher gain scores for the lecture format, and the males obtained the higher gain score for the programmed instruction format. Both sexes performed slightly better in the lecture situation than in the programmed instruction situation.

Figure 25

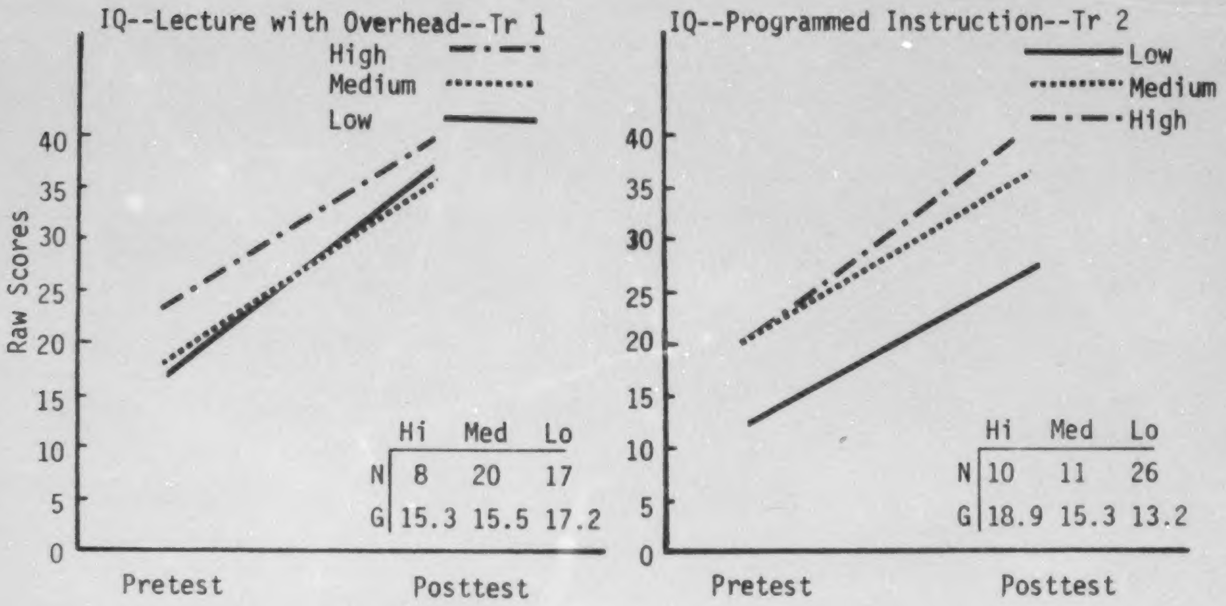
The Relationship Between Group and Performance
Across Two Instructional Modes



In terms of groups Whites scored higher on both the pretest and the posttest (PL 19.1, 23.9--PL 33.5, L 38.3) than Blacks (PL 12.0, L 16.9--PL 29.9, L 33.2) or Mexican/Americans (PL 14.5, L 16.7--PL 27.2, L 37.8). Blacks, however, had higher gain scores than Whites on both treatments and better than the Mexican/Americans in the programmed instruction treatment. In terms of gain scores, Mexican/Americans performed significantly better than any groups in the lecture setting and performed significantly better in the lecture setting.

Figure 26

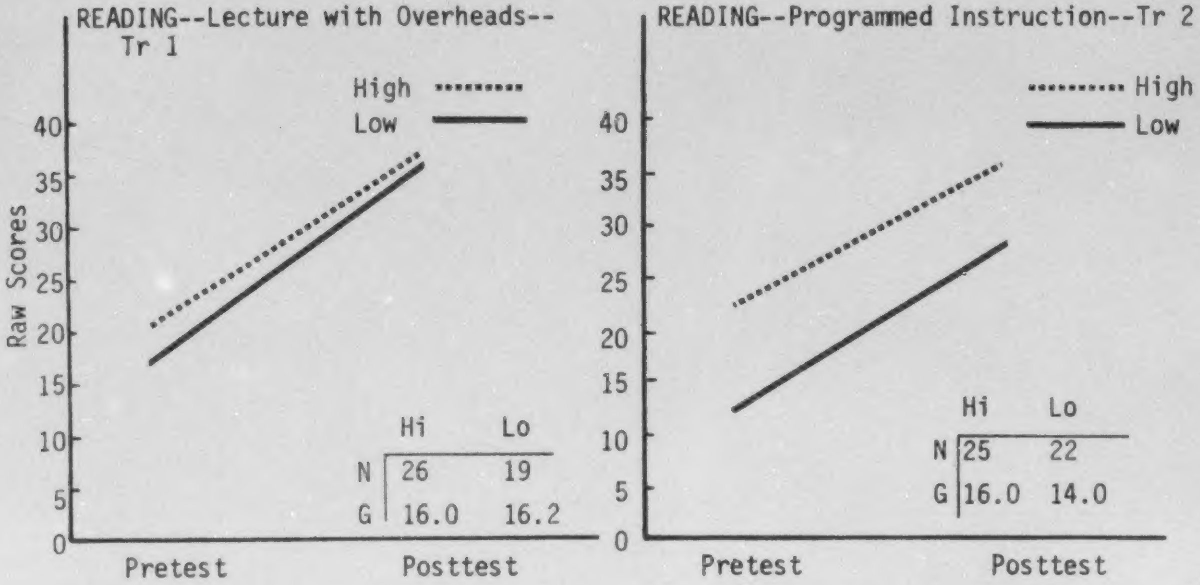
The Relationship Between IQ Levels and
Performance Across Two Instructional Modes



In terms of IQ, all three groups (high, medium, and low) performed about the same in the lecture format although the high group (IQ's above 90) scored somewhat higher than the medium group (IQ's 81-90) or the low group (IQ's 60-80). In the programmed instruction setting where reading was essential, the students with IQ's of 81 and above scored significantly higher (posttest: Pl 39.4 and 35.8) than the students with IQ's of 80 and below (posttest: PL 26.4). The low group obtained the highest gain score in the lecture format but the smallest gain score in the programmed instruction format.

Figure 27

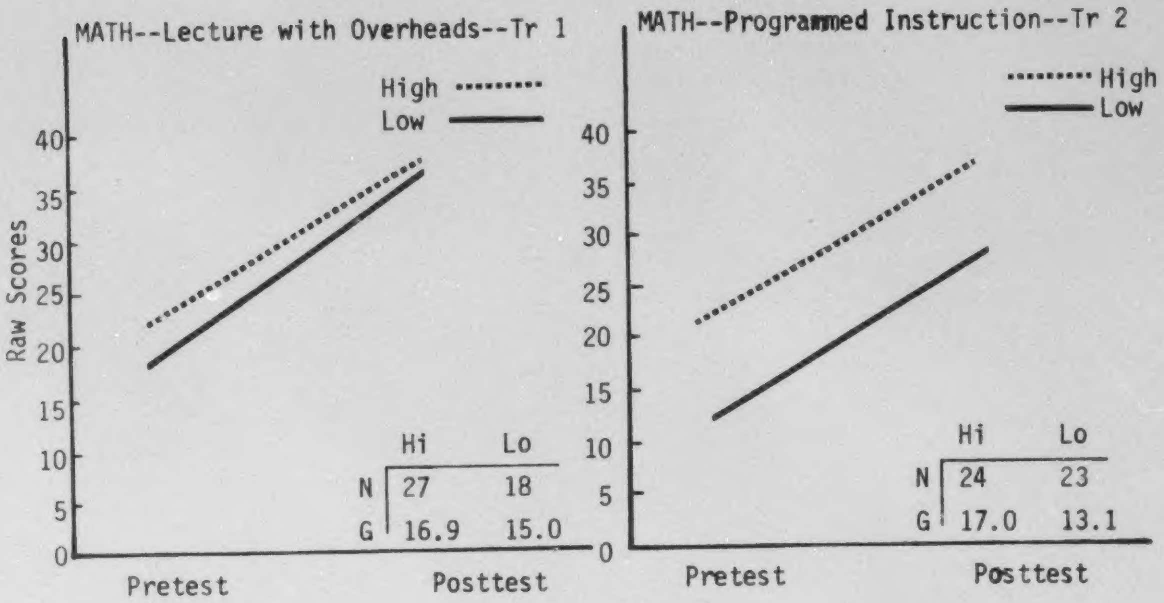
The Relationship Between Reading Achievement and Performance Across Two Instructional Modes



Students scoring above the 6th grade in reading ability scored significantly higher (posttest: 35.6) than students scoring below the 6th grade (mean: 5.2) in reading ability (posttest: 26.6) in the programmed instruction format. In a lecture format both groups performed similarly. Gain scores for both groups across both treatments were also similar.

Figure 28

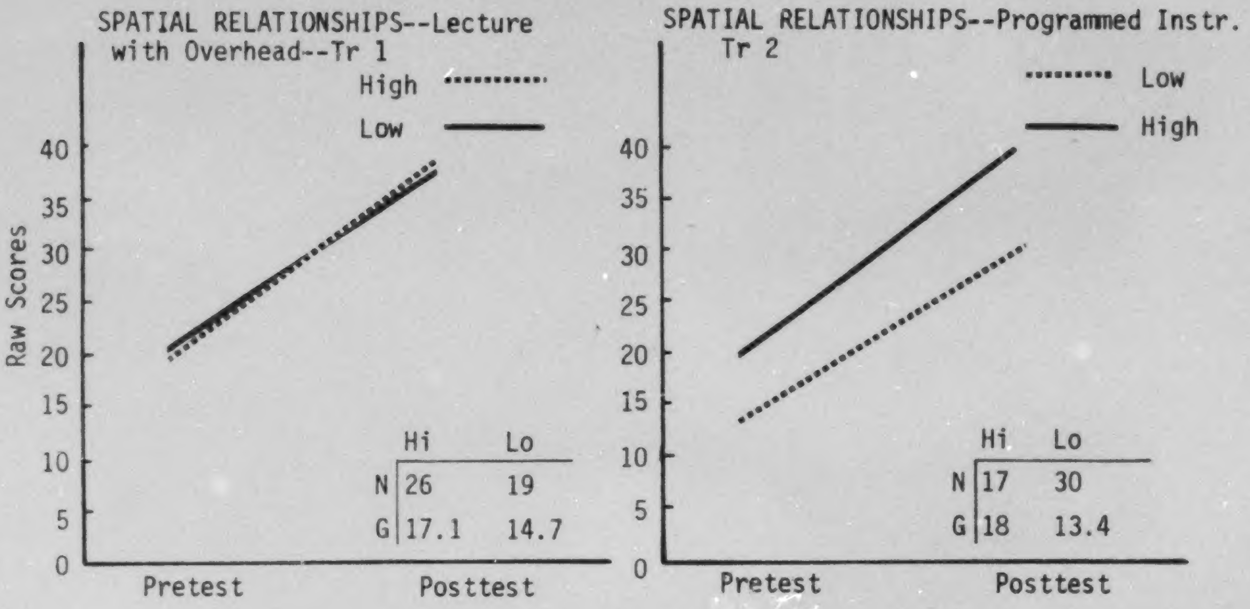
The Relationship Between Math Achievement and
Performance Across Two Instructional Modes



Performance across the two treatments in terms of math ability was nearly a carbon copy of performance as a function of reading ability.

Figure 29

The Relationship Between GATB S and Performance Across Two Instructional Modes



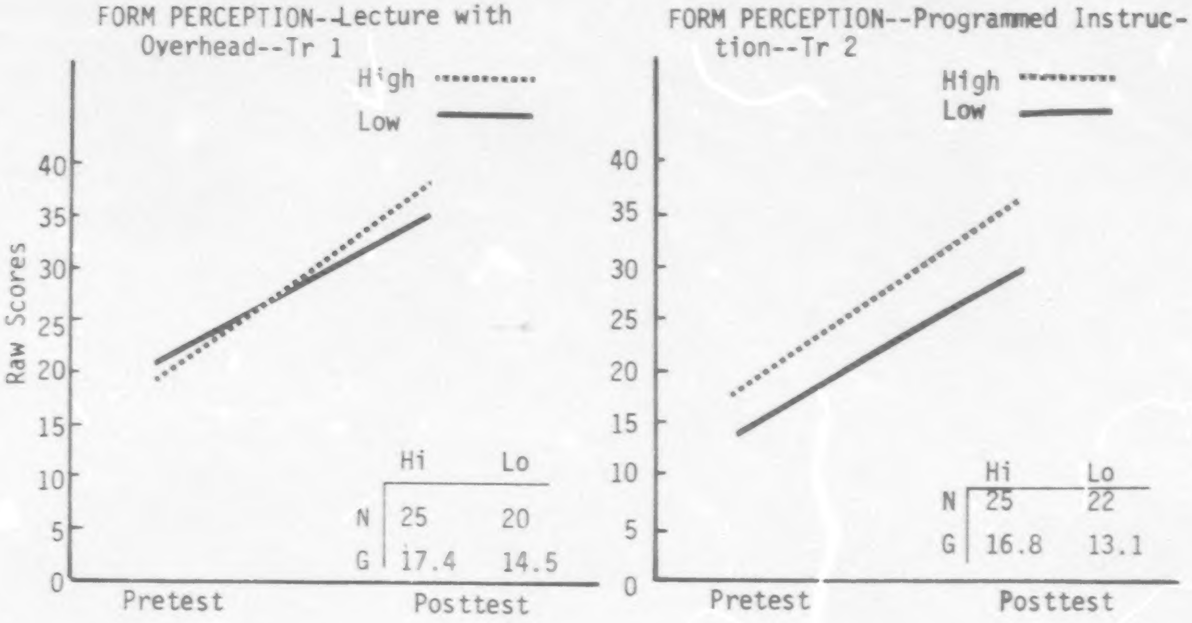
SPATIAL RELATIONSHIPS--Lecture with Overhead--Tr 1

SPATIAL RELATIONSHIPS--Programmed Instr. Tr 2

Students scoring high in spatial relationships (GATB subtest "S") performed significantly better (posttest: 38.1) than students scoring low on GATB S (posttest: 27.2) in the programmed instruction situation. There were no differences, however, in performance levels for the lecture situation. Gain scores were higher for the high GATB S pupils than the low GATB S pupils.

Figure 30

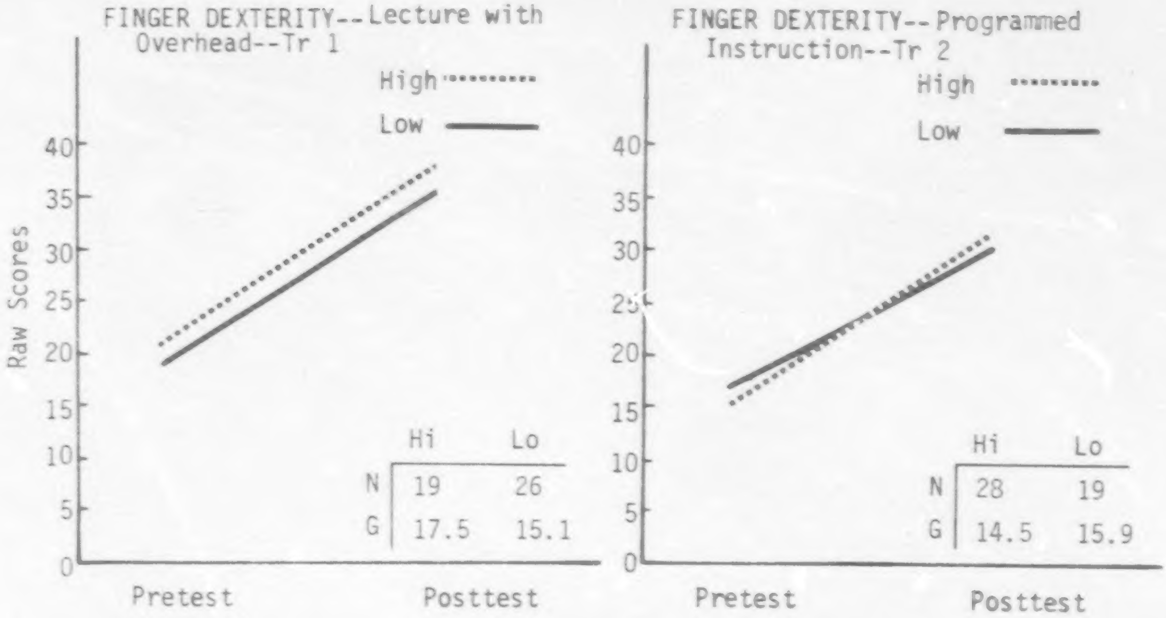
The Relationship Between GATB P and Performance Across Two Instructional Modes



Students scoring high in the GATB form perception subtest performed significantly higher (posttest: 35.2) in the programmed instruction mode than students scoring low on the GATB P subtest (posttest: 26.9). There were no significant differences between the groups in the lecture mode.

Figure 31

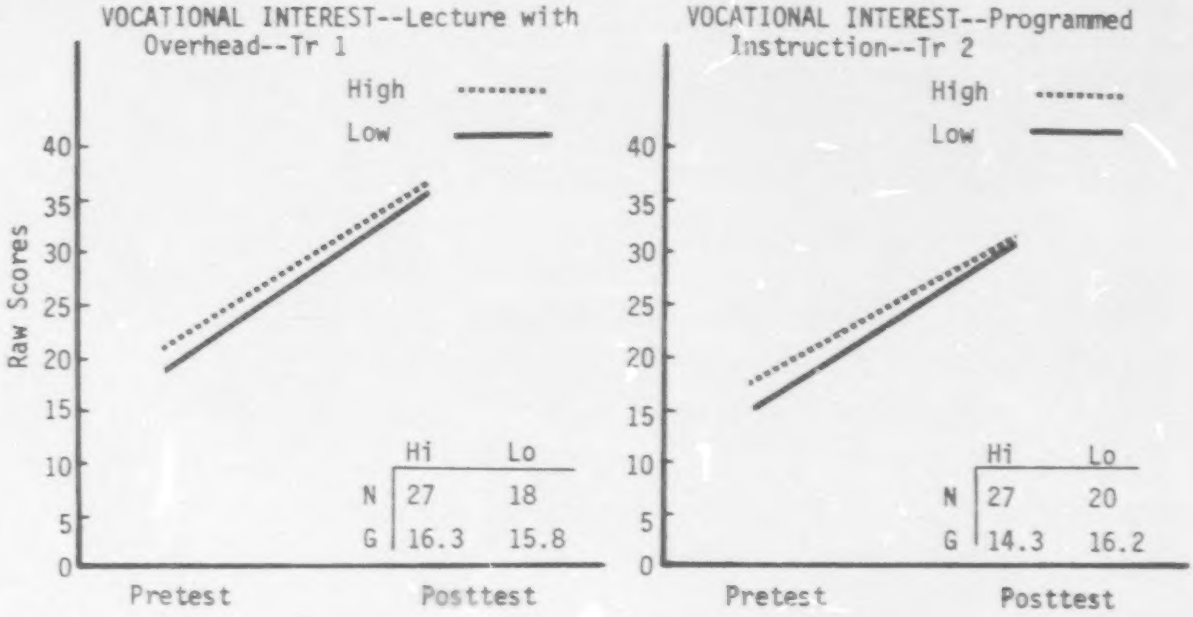
The Relationship Between GATB F and
Performance Across Two Instructional Modes



Finger dexterity did not significantly influence pretest or posttest performance for either instructional mode.

Figure 32

The Relationship Between Vocational Interest and Performance Across Two Instructional Modes



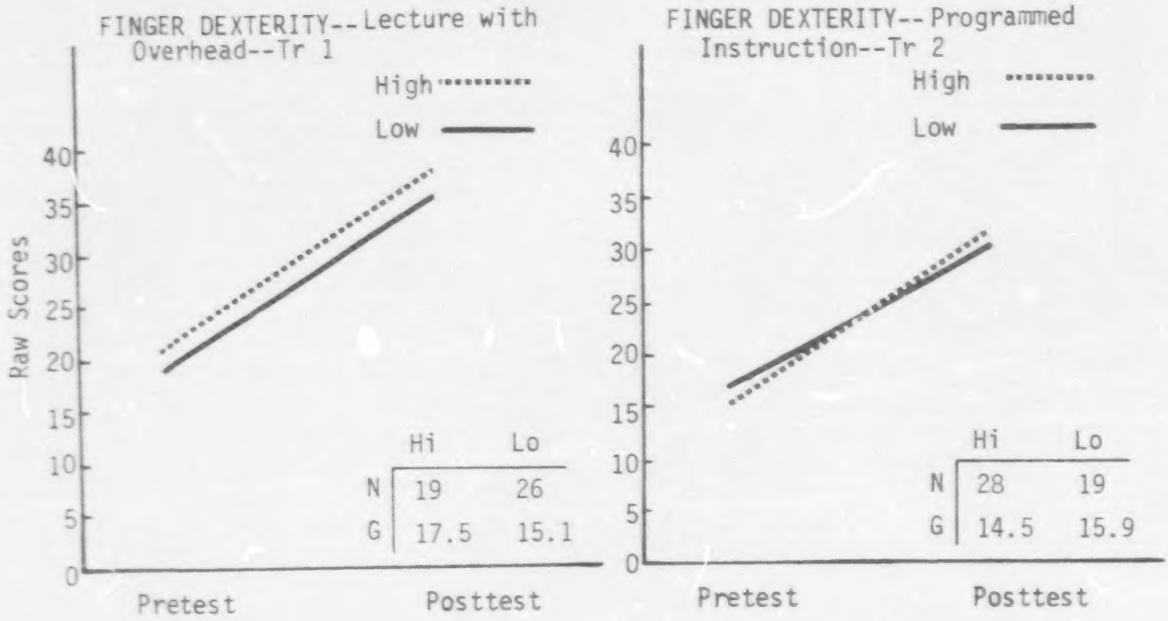
The relationship between high and low vocational interest and the two instructional modes was nonsignificant.

Summary

Numerous variables were investigated to determine the extent to which they influence the acquisition of vocational concepts by EMR, LLD, CVAE, and BT students. When instruction is based on concept teaching principles, learning appears to be significant for all groups of students. However, it was found in this study that gain scores as indicators of learning were affected by the manipulation of both instructional variables and by student characteristics. The implications of these basic findings will be discussed at length in Chapter 7.

Figure 31

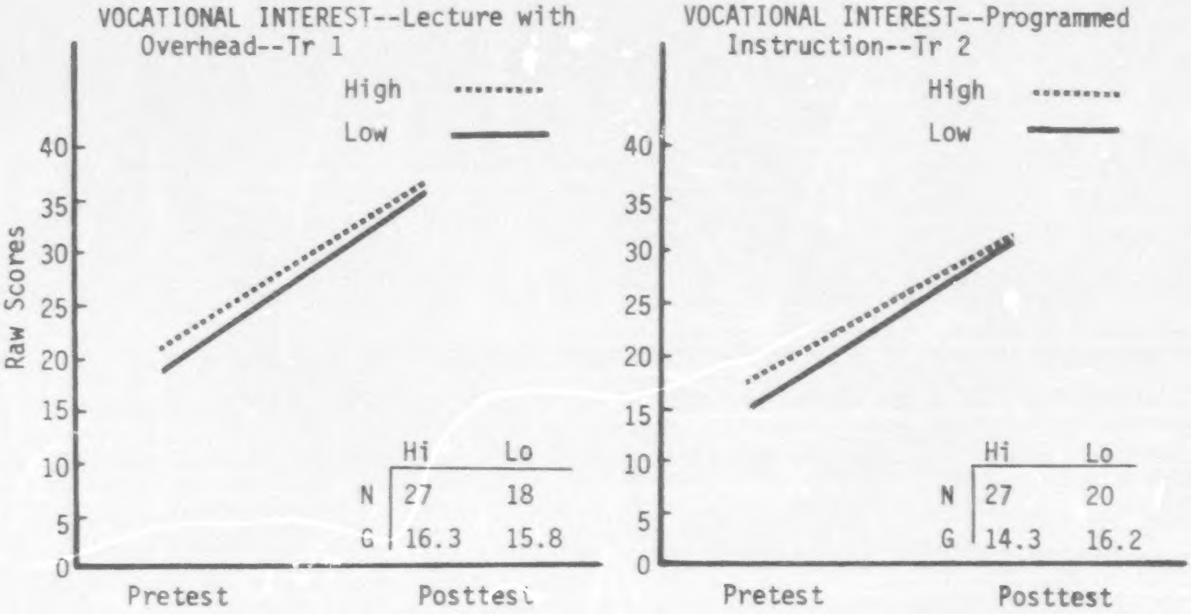
The Relationship Between GATB F and Performance Across Two Instructional Modes



Finger dexterity did not significantly influence pretest or posttest performance for either instructional mode.

Figure 32

The Relationship Between Vocational Interest
and Performance Across Two Instructional Modes



The relationship between high and low vocational interest and the two instructional modes was nonsignificant.

Summary

Numerous variables were investigated to determine the extent to which they influence the acquisition of vocational concepts by EMR, LLD, CVAE, and BT students. When instruction is based on concept teaching principles, learning appears to be significant for all groups of students. However, it was found in this study that gain scores as indicators of learning were affected by the manipulation of both instructional variables and by student characteristics. The implications of these basic findings will be discussed at length in Chapter 7.

CHAPTER 7: IMPLICATIONS OF THE FINDINGS

The findings of this study have numerous implications for teachers whose task it is to convey concepts to vocational students. It must be emphasized at the outset of this discussion, however, that the process of determining implications from the statistical findings of a study is an individual matter. The responsibility of the researcher is to discuss conservatively all that the data seems to imply. The reader, however, has both the option of inferring more from the data than what the researcher chooses to imply and the option of questioning the validity of what is implied.

Performance Differences Between Four Student Groups

In Sub-Study 1, students classified according to TEA guidelines as educable mentally retarded (EMR), language and learning disabled (LLD), and disadvantaged (CVAE) were assigned to a learning task together with a group of building trades (BT) students. The purpose of this sub-study was to compare the performance of the various groups to determine to what extent, if any, the groups would differ in learning a vocational concept under identical instructional conditions. It was found that the performance of BT students was significantly better than that of the other groups on the pretest. This finding, of course, came as no surprise because it was assumed that the prior learning of the concepts used in the study would be greater for BT students than for the other groups. The superior performance of the BT students was again evident in the initial posttest scores; however, the superiority was perhaps more a factor of their overall superior entry level performance than of superior learning from the lesson given as a part of the treatment. In terms of actual learning as measured by gain scores (posttest minus pretest performance), the LLD students showed the best overall performance. The EMR students performed as well as the BT students and the LLD, EMR, and BT students all performed better than the CVAE students. Statistically speaking, though, none of the differences between the groups were significant, both in terms of immediate posttests and in terms of delayed posttests. The findings imply that the differences in the performance of EMR, LLD, CVAE and BT students is minimal on a concept learning task of the difficulty level used in this study.

An explanation is needed to account for the fact that the treatment had more of an effect on learning for EMR and LLD students than for CVAE or BT students. A possible explanation is that the CVAE and BT students found the materials too elementary to command their interest and attention. EMR and LLD students may be more accustomed to materials which present concepts in very precise and small steps. Another explanation for the superior gain scores (proportionately speaking) for the LLD and EMR students is that their gains were made only for the simplest concepts which the CVAE and BT students identified on the pretest. The remaining concepts may have been more difficult to acquire thereby giving a handicap to the CVAE and BT students.

There is, however, the distinct possibility that LLD and EMR students are as efficient in learning concepts (under the circumstances of this study) as are CVAE and BT students. It is time, at least, for the learning potential of handicapped students to be recognized for how near it is to normal levels of proficiency rather than how retarded or handicapped it is. The same can be said for the retention of concepts over periods of seven and 30 days.

The Effects of Speech Rates on Learning

In an investigation of the effects of time-compressed and time-expanded speech on the learning of vocational concepts, it was found that there were no significant differences in the performance of students assigned to the various speech rates. In terms of presenting concepts equivalent to those used in this study, it can be implied that both original instruction and supplemental practice on a concept could be conducted at the rate of 225 wpm without hindering learning. Similarly, for the sake of providing variety for students who are assigned to auto-instructional programs or supplemental assistance programs, a wide range of speech rates can be used without adversely affecting learning.

Students assigned to 75 wpm became quickly bored with the treatment and continued to listen to the lesson more as a favor to the experimenters than as information in which they had inherent interest. The EMR students appeared to be as bored with the 75 wpm as the other students, although their performance at this level was not affected. In short, our experience would indicate that time-compressed speech has a potentially meaningful application in vocational instruction but its application to individualized instruction requires further investigation. There may be individuals interested in learning through the use of time-expanded speech, but the teacher should be aware of its effect on behavior.

The Effects of Technical Terms on Learning

A second sub-study dealing with oral presentation variables sought to determine how well EMR students perform under different levels of complexity of language. One group received instruction in which numerous technical terms were used, and a second group received instruction in which very few technical terms were used. Both treatments were administered by taped transcriptions with identical visual materials. In terms of performance, the two groups had nearly identical gain scores on an initial posttest; and their posttest scores also did not differ significantly.

There are at least two implications that may be derived from these findings. First, it is possible that the moderate and careful use of technical terms is more advantageous for the mentally handicapped than the use of watered-down substitutes which frequently are confusing because of their verbosity. If we accept the premise that language has evolved as a tool to simplify the act of communicating, it is possible that technical terms simplify rather than complicate communication. Second, there is an implication from the data that the concepts presented in the study could have been learned without either technical terms or their nontechnical word substitutes. The visuals themselves may have communicated sufficient information to make it unnecessary for the students to rely on the accompanying oral presentation for additional information. Nevertheless, the judicious use of technical terminology may be more beneficial in vocational instruction than avoidance of technical terminology. The closer that instruction parallels the circumstances of the world of work the greater the transfer of training, thus technical language may have a very legitimate place in vocational education.

The Effects of Various Visual Presentation Modes on Learning

A fourth sub-study sought to determine the influence on learning of various visual presentation modes. The optimal amount of pictorial detail to present in the instruction of particular concepts has long been a topic of research. Findings have been inconclusive, however. Line drawings have been shown to be superior to detailed visuals in certain cases and not significantly superior in others. Vocational teachers are often engaged in teaching the names, functions, and operating procedures for various mechanical implements. This does not necessarily imply, however, that actual objects need to be used initially for instructional purposes. There is evidence that for introducing certain concepts, especially those in which form or shape are critical properties, that line drawings may be of greater instructional value than other visual formats, because they can be made to eliminate many irrelevant characteristics otherwise associated with a concept. For practical purposes, on the other hand, actual objects may often be the preferred visual stimulus for instruction.

In a comparison of different visual modes, this research project found that line drawings were the easiest to prepare, the least expensive to prepare, and were one of the most efficient visual modes for conveying concepts. In addition, because line drawings eliminated much irrelevant information, they allowed the student to focus on the critical attributes of the concepts to be learned.

Photograms (shadowgraphs) were of little use eventhough they were easy and inexpensive to produce. They were excellent for conveying outlines, but they should be used sparingly and predominantly for special effects.

Photographs, it was found, can be costly to produce but have the advantage of easy transportability and can be used in the same manner as flash cards for periodic reviews of concepts previously learned.

Of the various detailed pictorial modes, 35mm. slides were the most effective in this study. The fact that they conveyed extraneous detail such as color did not distract from effectiveness. The argument could be made, moreover, that by enabling the students to see a particular bolt in several different colors that he would not be confused by various colors in a transfer of training situation in which real objects had to be identified. Slides have the disadvantage of limited transportability (unless every room in which they will be used is equipped with a slide projector), but they have the advantages of relatively inexpensive production cost and adaptability for individual or large group learning.

In a related sub-study, an investigation was made of the effectiveness of line drawings versus actual objects as visual stimuli. In this study both treatments were administered to a maximum of three or four students per setting, thereby encouraging maximum interaction between the students and the experimenter. In terms of gains scores, there were no significant differences between the groups. Original learning was excellent for both visual modes. As an informal supplemental investigation, a small number of students were retested using the opposite visual mode in which they received instruction. Again, retention was excellent and the transfer of learning from one mode to the other did not hinder performance of the students.

The implication of this sub-study is that actual objects, if they are simple items such as bolts and screws, can be used as effectively as line drawings which reduce for the learner the number of noncritical attributes thereby accentuating the critical properties to be learned. It would appear that the complexity of the concept to be taught would dictate whether line drawings should first be introduced and then followed by the use of actual objects or whether actual objects should be used exclusively. Although there were no differences in the gain scores for the two treatments, both groups performed at levels that appeared to be superior to the performance of the students in the previous sub-studies.

The Effects of Group Size on Learning

The students assigned to line drawings in Sub-Study 3 received identical instruction to those assigned to line drawings in Sub-Study 4. The students were participating in identical programs (in terms of curriculum) and were matched in terms of IQ and other ability factors. The obvious difference in the two treatments was that one group received instruction in a large group setting (approximately 20 students) and the other group received instruction in a small group setting (a maximum of four students). Informally, it was observed that the rapport between the experimenter and the students was much greater for those in the small group setting. Because the rapport was greater, the attention and interest of these students appeared to be more intense than the students assigned to the large group setting. The implication, though tentatively stated, is that group size and more specifically, teacher-pupil rapport may have a significant effect on the learning of concepts.

Again, in the small group setting the students appeared to be much more conscious of the performance of their peers. If one student, for example, showed enthusiasm for the exercise and appeared to be answering the questions with relative ease, other students in the small group were also likely to show some enthusiasm. In the large group setting, if one student showed enthusiasm for the exercise, it had no effect on the other members of the group. It must be noted, of course, that the reverse could also occur. In the small group, if one student rebelled at the exercise or was in a bad mood for one reason or another, this individual's behavior adversely affected the attending level of the other group members whereas in the large group setting unenthusiastic participation by one or two members of the group had very little effect on the overall group attitude toward the exercise.

The Effects of Pupil/Teacher Rapport on Learning

In a second sub-study experimenter/pupil rapport again appeared to have a significant impact on the performance levels of the students. LLD students in one school were assigned to listening booths in a language laboratory. The boothes were supervised by an individual unfamiliar to the students. The treatment was given with virtually no interaction between the pupils and the experimenter. The identical treatment was administered to a second group of LLD students but in this instance, the students remained in their homerooms with their regular teacher. Further, the experimenter interacted closely with the students--explaining the procedures for taking the tests, adjusting the headsets and volume controls on the audio equipment, and attending to any questions or comments raised by the students. The performance of the high rapport group was significantly superior to the low rapport group. Again, it was implied that pupil/experimenter rapport plays an important role in the learning of vocational concepts.

Individualized Instruction Versus Group Instruction

In a fifth sub-study, the question was raised: Is a group lecture with overhead visuals more or less effective in conveying concepts than a self-instruction format using programmed booklets? Approximately 45 CVAE students were assigned to each treatment. The students were matched in such a way as to have an equal number of high-ability and low-ability students assigned to each treatment. The result of this matching procedure is clearly reflected in the closeness of means for such traits as: reading ability (6.1, 6.2), math ability (6.3, 6.1), and IQ (83.7, 80.5).

For the 92 CVAE students participating in the study, there were no significant differences in the performance levels of students assigned to the two instructional methods. The group lecture method (gain score, 16.09) was only slightly higher in terms of gain scores than the programmed booklet method (gain score, 13.71). Upon further analysis, however, it was found that the lack of significant differences in the two treatments was attributable in large measure to the heterogeneity of the groups. For specific sub-groups (characterized by levels of selected traits), the treatments had a preferential effect which will be discussed in the following paragraphs.

Sex. In terms of sex, neither treatment was superior. Males outperformed females in both treatments on both the pretest and the posttest. The gain scores between the sexes for programmed instruction were separated by a greater margin than for the group lecture with overheads format. With the males profiting more from programmed instruction than the females.

Group. The performance of students by group, like sex, was not significantly different between the two treatments. Across both treatments, Whites outperformed Blacks on the pretests and posttests. Blacks and Mexican Americans performed at the same levels in the programmed instruction and on the pretest of the group lecture treatment. However, the posttest performance of the Mexican Americans was higher than that of the Blacks on the posttest for the lecture approach. The mean gain score for the Mexican Americans assigned to programmed booklets was 13.2, and the mean gain score for the Mexican Americans assigned to the lecture with overheads format was 21.2. The possible implication here is that Mexican Americans (especially those whose predominant language is Spanish) should be instructed in methods requiring a minimal amount of reading in English.

Reading. For students classified as high- and low-ability readers, there was no difference in pretest and posttest performance for the lecture with overheads treatment. There were marked differences, however, in pretest and posttest performance within the programmed instruction treatment. The high-ability readers in the programmed instruction format had a pretest mean of 19.6 and a posttest mean of 35.6. In contrast, the low-ability readers in the same treatment had a pretest mean of 13.1 and a posttest mean of 26.6. For this treatment, the two groups were separated by approximately 10 points in their posttest scores.

The implication from this particular analysis is that high-ability readers perform about as well in a lecture with overheads situation as in a programmed instruction situation. Low-ability readers, on the other hand, are not handicapped by the lecture with overheads approach, but are significantly handicapped by the programmed booklet approach.

Math. The performance of students classified as high- and low-ability in math was almost a perfect carbon-copy of the performance of students classified by reading ability. Both classifications performed equally well with the lecture with overhead treatment, but in the programmed instruction treatment there was a marked superiority of the high-ability students over the low-ability students.

Vocational interest. The treatments had no differential effects on the performance of students classified according to high- and low-vocational interest (as determined by the Kuder Interest Inventory).

Spatial relationships. Like IQ, reading, math, and Form Perception, performance scores were differentially affected by the spatial relationships subtest of the GATB. There were no differences between high- and low-scoring students for the lecture with overhead treatment. There were significant differences, however, between the high- and low-scoring students assigned to the programmed booklets. The high-scoring students on the GATB spatial relationships subtest scored approximately 10 points higher than the low-scoring students on both the pretest and the posttest. The implication is that students performing low in the spatial relationships subtest of the GATB should be instructed to the extent possible with nonreading materials.

Form perception. In a lecture with overheads treatment, students scoring high in the form perception subtest of the GATB performed identically to students who scored low. In a programmed booklet treatment, high-scoring students on the GATB form perception subtest performed significantly higher than low-scoring students for both the pretest and the posttest. The implication is that form perception correlates significantly with IQ, reading, math, and GATB P as a predictor of performance with written materials. Lectures, discussions, demonstrations are more effective with low-scoring students in the GATB P than are programmed booklets.

Finger dexterity. The two treatments used in this study did not distinguish in any way between the performance of students who scored high in the finger dexterity subtest of the GATB and students who scored low.

IQ. In this study, students assigned to the lecture with overheads treatment did not differ significantly as a function of intelligence level. Students assigned to the medium and low IQ groups (in terms of this study only) performed at the same level, and students in the high group (in terms of intelligence groups for the study) scored a few points higher on both the pretest and the posttest.

Summary

Teaching concepts to students with special needs calls for the systematic control of numerous variables. Therefore, for instruction to be optimally effective, extensive preparation is required. The popular ad lib approach to teaching is grossly inadequate for effectively and systematically teaching vocational concepts. As a minimum, the act of teaching a vocational concept should be preceded by (1) the selection (or adaptation) of a specific concept presentation strategy, (2) an analysis of the essential and nonessential attributes of the concept to be learned, (3) the selection of a sufficient variety of examples and nonexamples to portray each essential and nonessential concept attribute, (4) the preparation of instructional materials which clearly point out the essential attributes of the concept, and (5) the preparation of a pretest, a posttest, and practice tests to measure attainment of the concept to be learned.

At first, this list of steps to be followed may seem like a formidable set of tasks to perform for every concept to be taught. In actuality, as this approach is repeatedly used, the steps become sufficiently systematic so that they blend into a single act of teaching. Moreover, the observant teacher by taking note of the effects on learning caused by the manipulation of different variables can become highly efficient in concept teaching.

In heterogeneous classes where students of several ability levels must be simultaneously instructed, it would appear that a straight-forward, clear lecture-demonstration is one of the most efficient instructional approaches that can be used. In this study, written materials (so often associated with individualized learning approaches) were clearly less effective than a lecture with overhead visuals format for students with reading levels below the 6th grade (something common for EMR, CVAE, and LLD high school students).

Another conclusion based on this study is that students will learn concepts more quickly and efficiently if they have been taught all of the prerequisite concepts that are in some way related to the concept to be learned. Pretests (both formal and informal) are an effective means of assessing the attainment of prerequisite concepts. When it is found that prerequisite concepts have not been attained, then instructional goals must be changed and supplemental instruction must be given, or the concept to be learned will be only partially attained (understood) resulting in future misconceptions and additional problems in attaining subsequent related concepts.

Line drawings and actual objects (or the two in combination) are effective visual presentation modes for teaching concepts, but other visual formats will also suffice in most instances. Similarly, different rates of speech can be used without hindering learning depending on the purpose the instructor may have for using variable rates of speech.

Small group instruction in which the teacher and the student have good rapport (appreciate one another, if you will) is a desirable setting for effective concept teaching.

Clear presentations of information supplemented with frequent reviews and summaries (often given in the form of review questions) are essential to efficient concept formation regardless of whether the information is conveyed by a teacher, by a mechanical device, or by printed material. Active presentations, however, appear to be superior to passive presentations (mechanical devices and written materials) for most students with special needs.

Finally, concept teaching will be consistently effective only to the extent that the teacher remains in control of the variables which affect concept learning--a task that this study has found both possible and rewarding.

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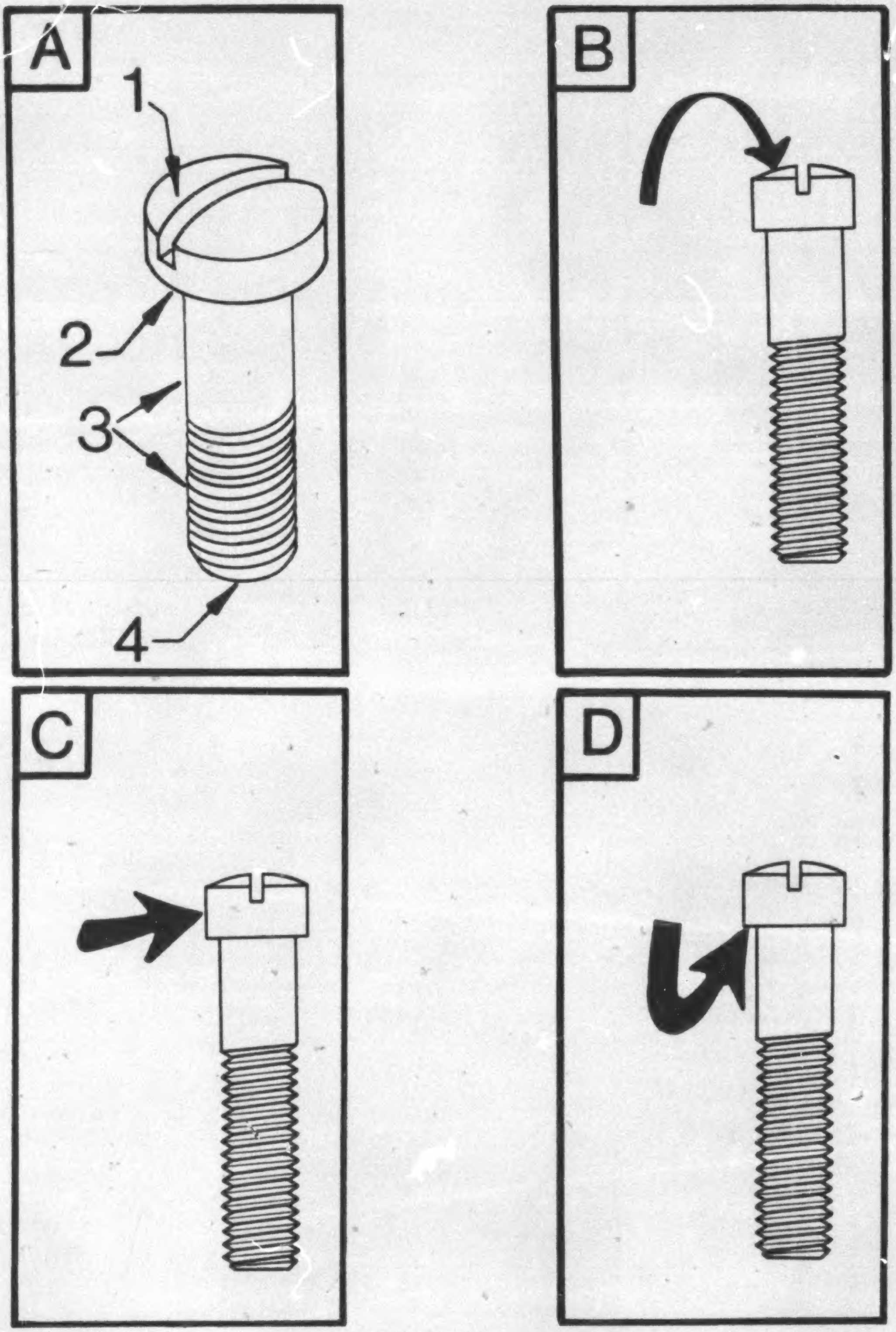
APPENDIX A

Sample of the Instructional Materials*

* The following materials are a sample of the content found in the instructional booklets given to the students who participated in the study. The materials are based on the procedures for teaching concepts which were identified in an extensive review of the literature. The materials were accompanied by an audio transcription, the text for which appears in Appendix D.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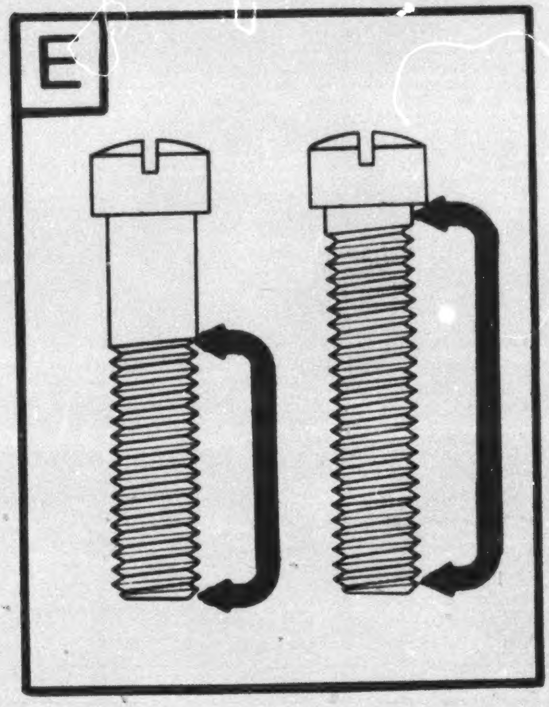
3
4
B
C
D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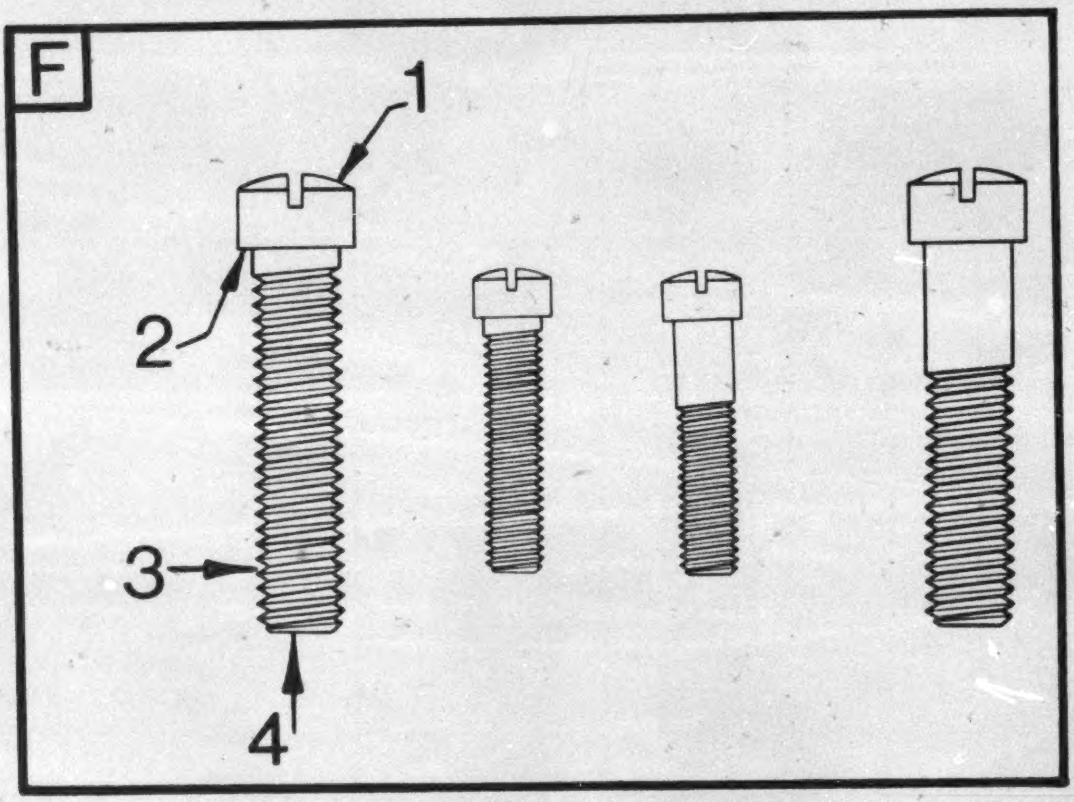
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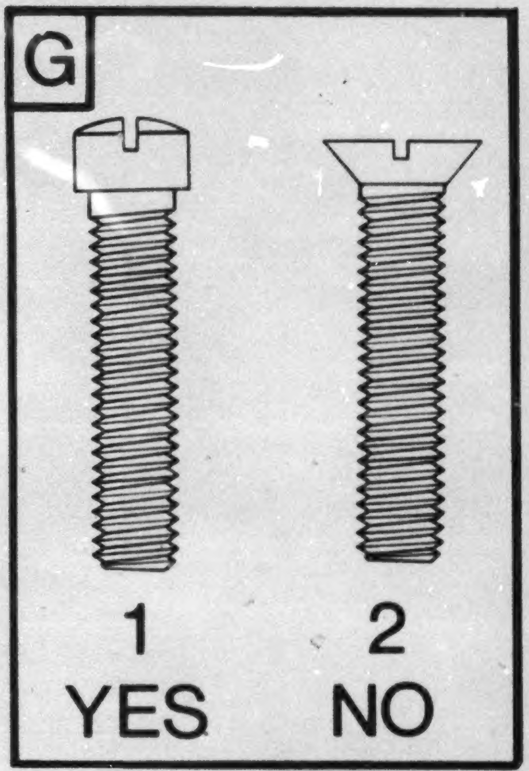
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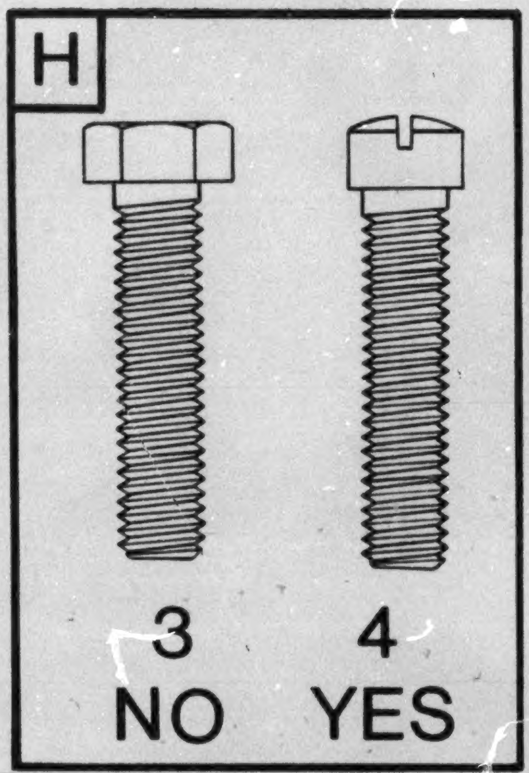
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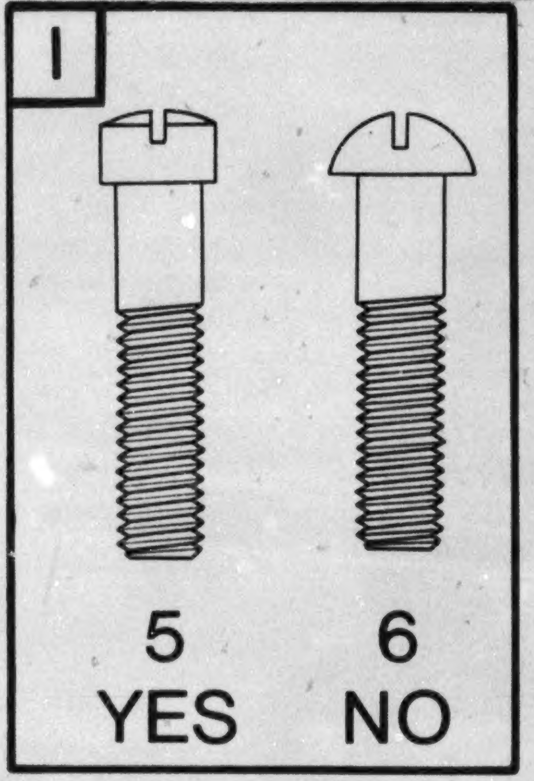
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6
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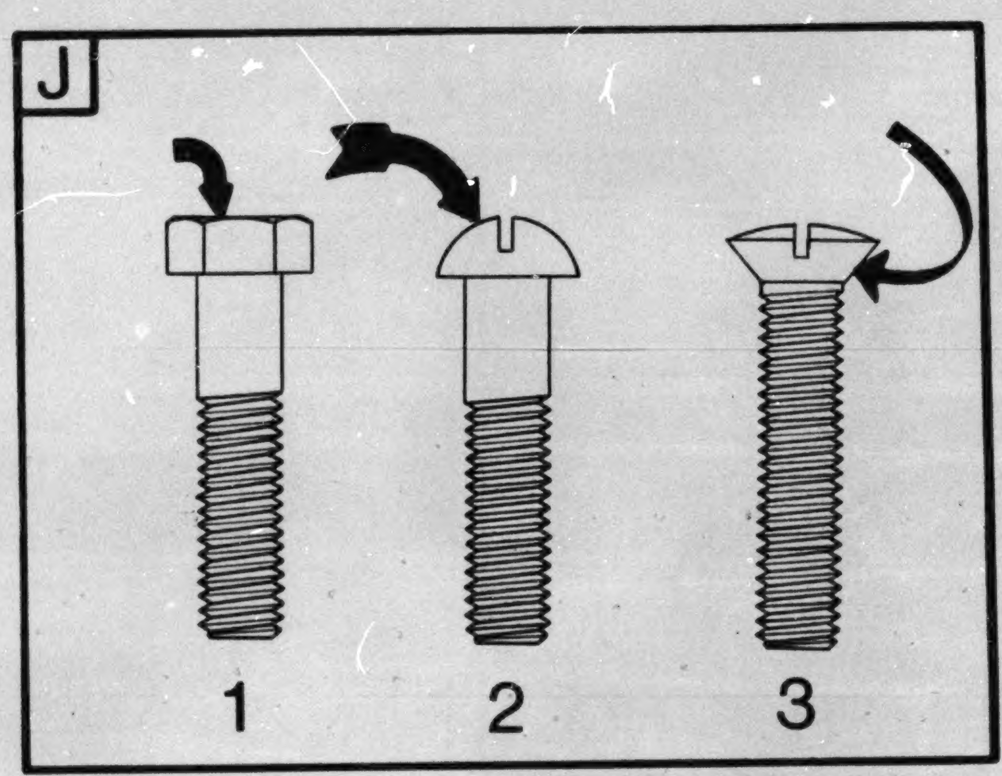
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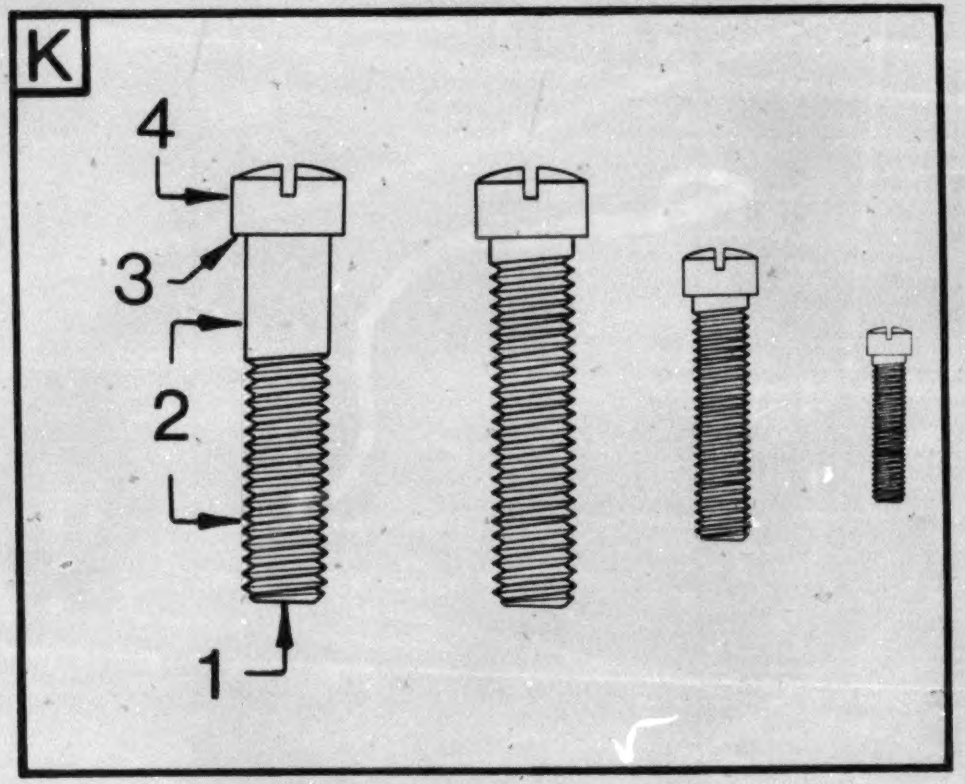
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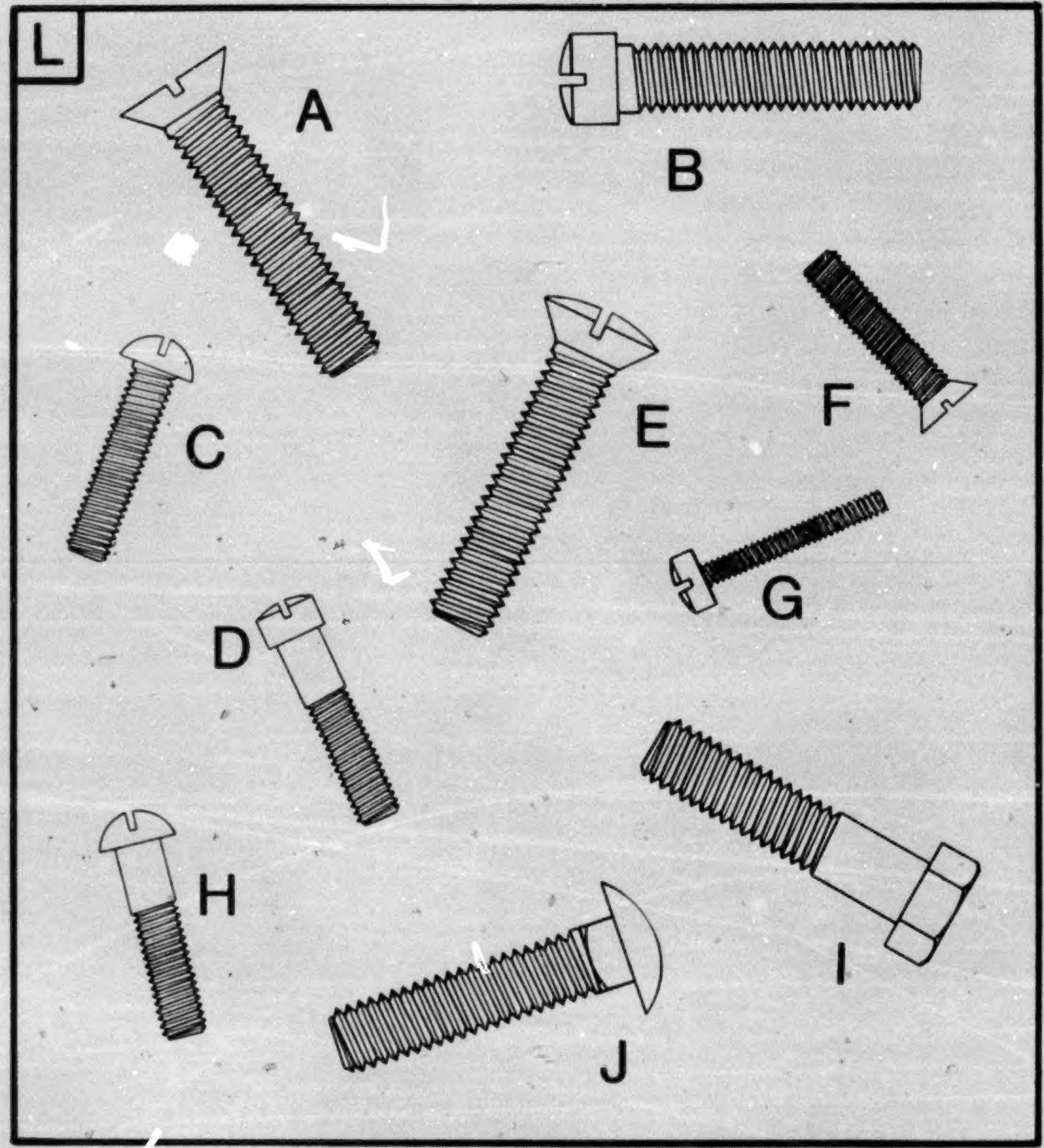
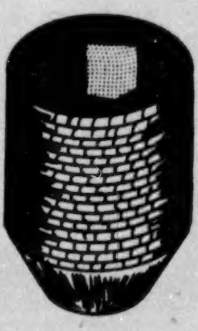

L
A
B
C
D
E
F
G
H
I
J

ANSWERS __ __ __ __ __ __ __ __ __ __ __

APPENDIX B

Samples of: Detailed Drawings
Photographs
Photograms
Programmed Booklets

L



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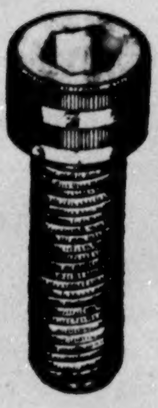

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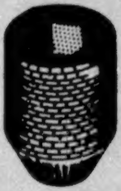
M



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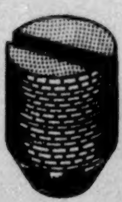

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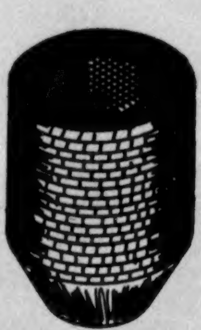
N



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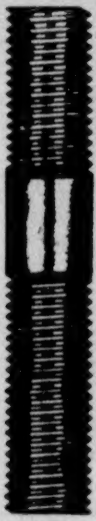

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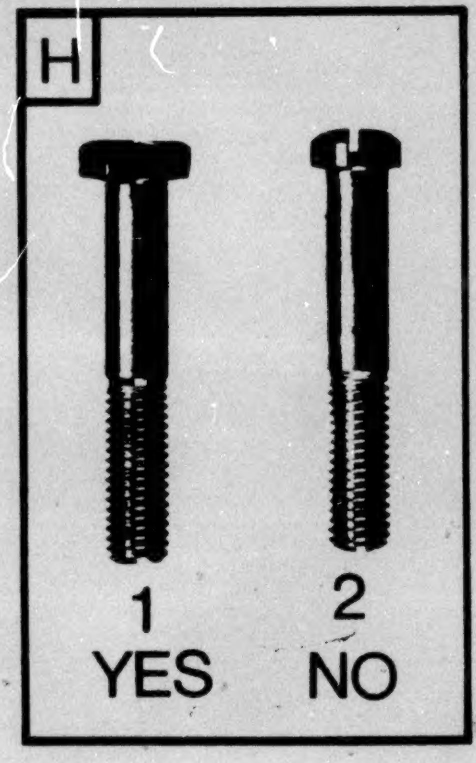
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2
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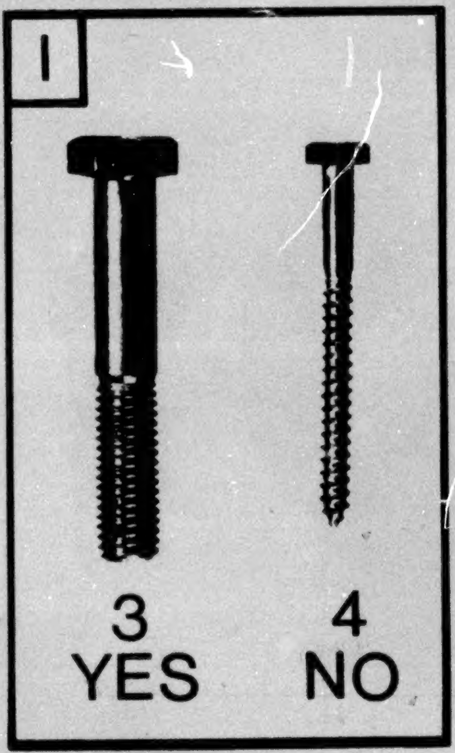
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4
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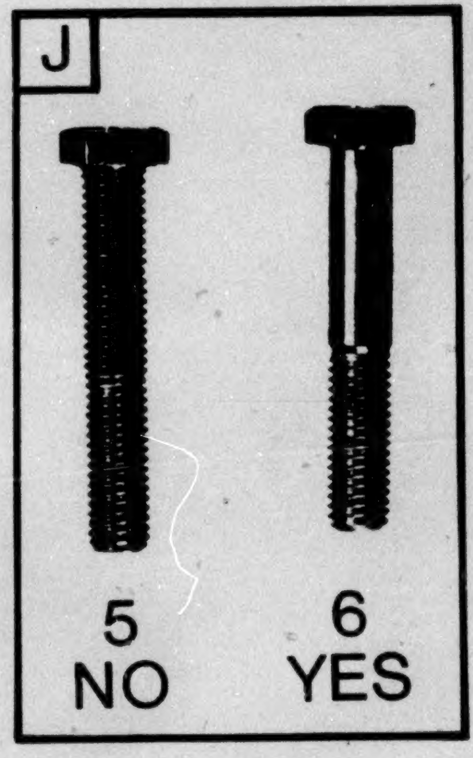
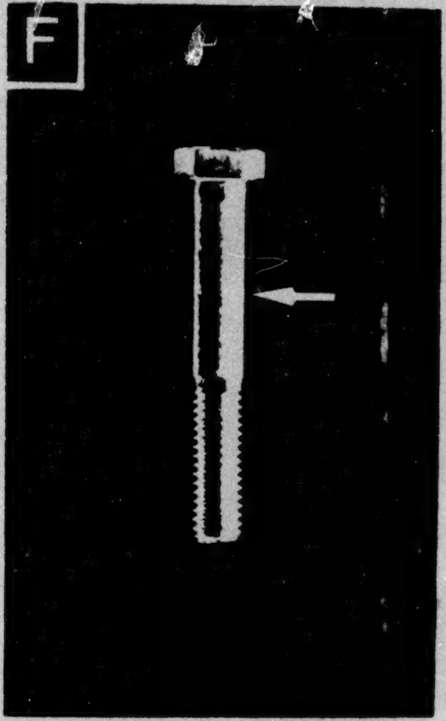

J
5
NO
6
YES

E

F



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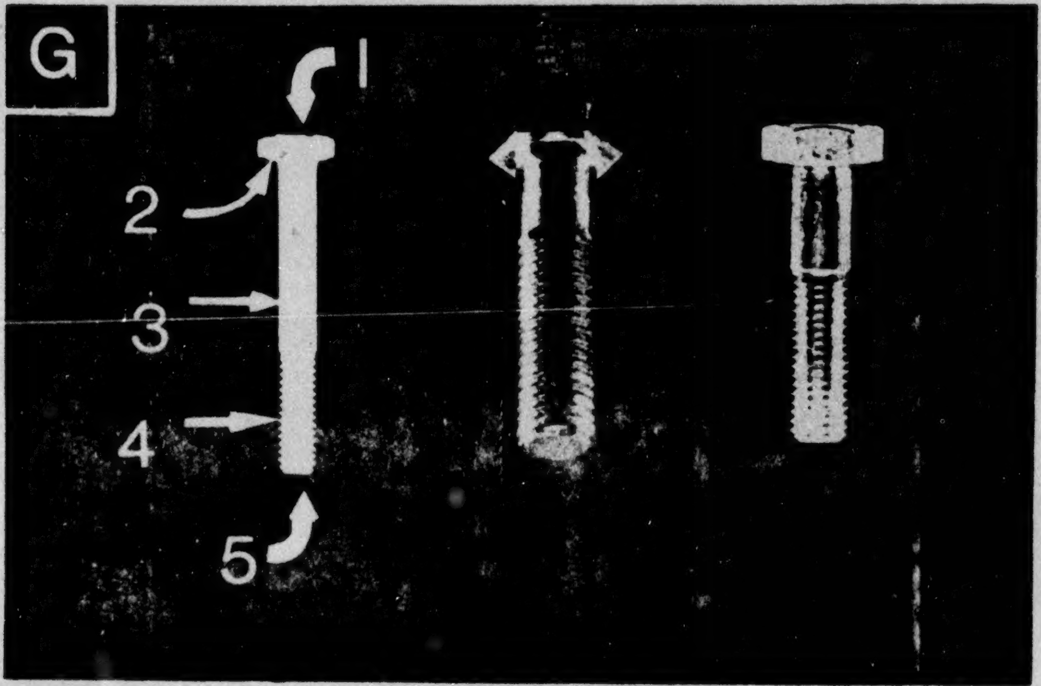
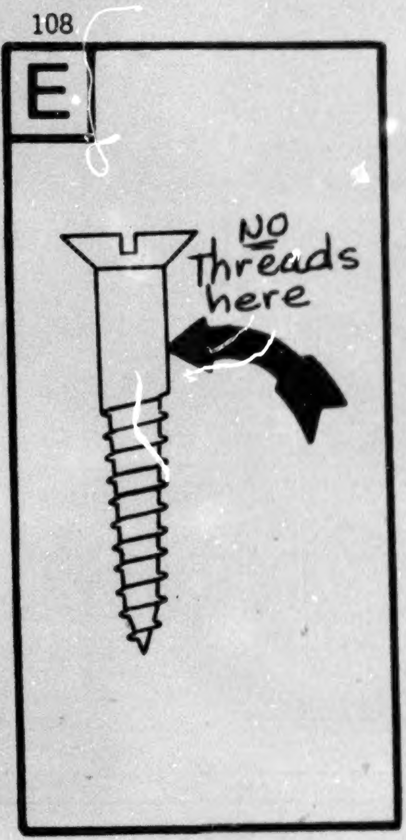
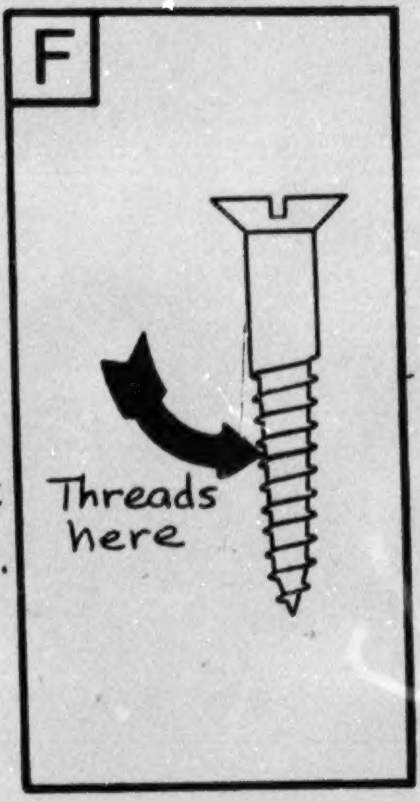
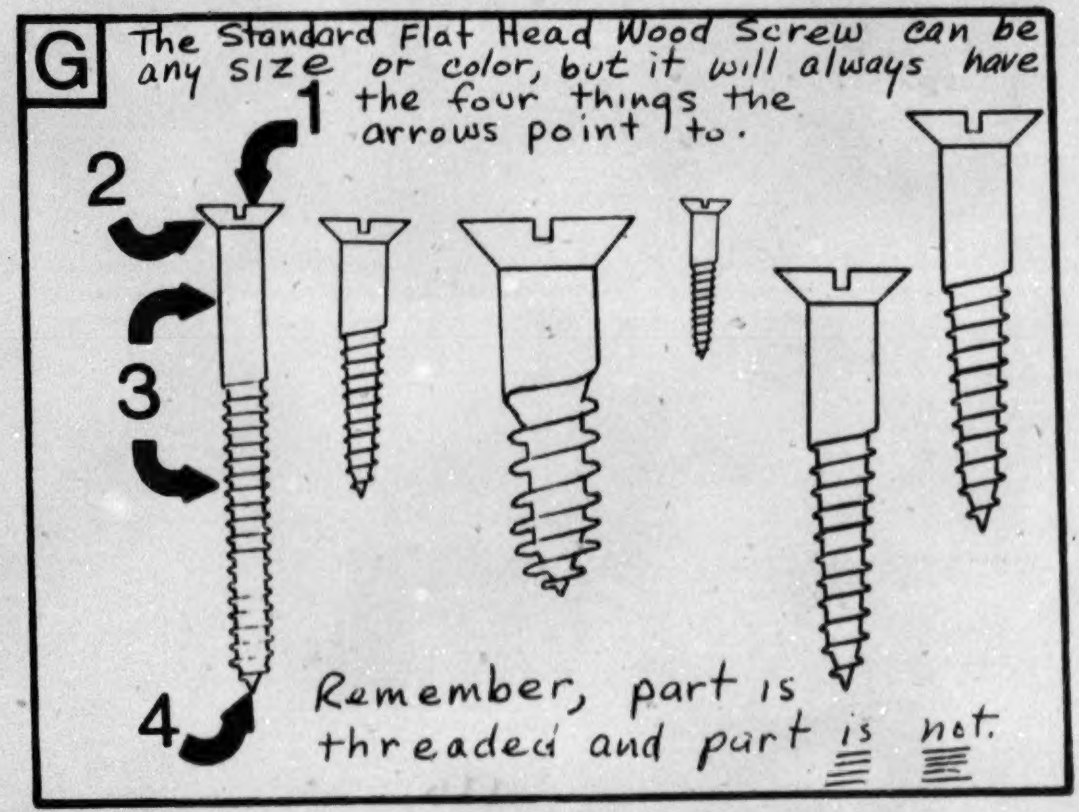



E
NO Threads here

This is the most important thing to remember. Part of the Standard Flat Head Wood Screw has threads and part does NOT have threads.


F
Threads here



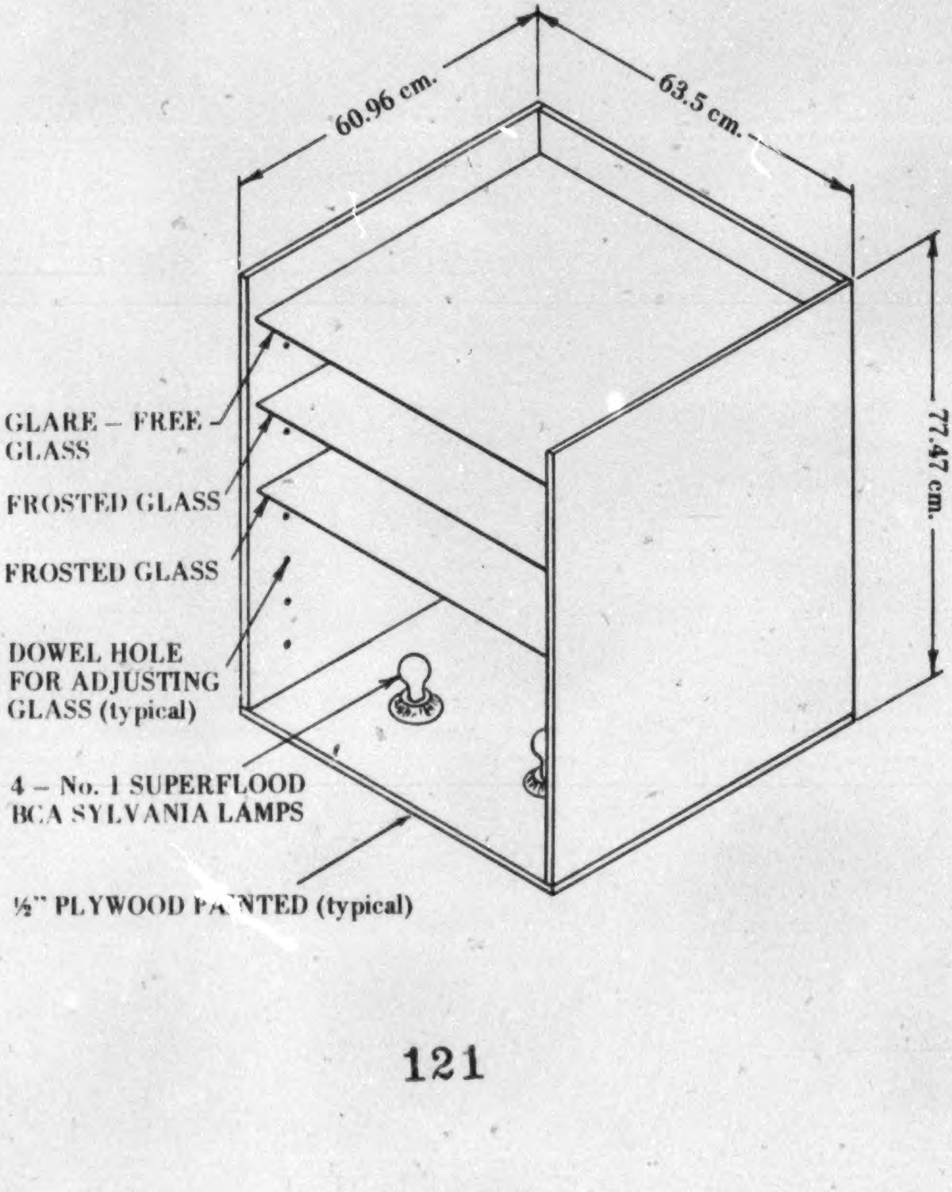
The Standard Flat Head Wood Screw can be any size or color, but it will always have the four things the arrows point to.

Remember, part is threaded and part is not.

APPENDIX C

Diagram of the Shadowless Box

THE SHADOWLESS BOX


60.96 cm.
63.5 cm.
77.47 cm.
GLARE – FREE GLASS
FROSTED GLASS
FROSTED GLASS
DOWEL HOLE FOR ADJUSTING GLASS (typical)
4 – No. 1 SUPERFLOOD BCA SYLVANIA LAMPS
½" PLYWOOD PAINTED (typical)

APPENDIX D

Technical and Nontechnical Script for the Fillister Head Cap Screw

Technical Script for the
Fillister Head Cap Screw

Look now at Box A where you will see a fillister head cap screw. To tell the fillister head cap screw apart from other bolts and screws you should look for:

1. a cylindrical head that is slotted and slightly rounded on top,
2. a bearing surface that forms a right angle with the body,
3. threads that go part way or all the way up the body, and
4. a flat base.

In Box B, you can see that the top of the fillister head cap screw is slightly curved or rounded.

Observe in Box C that the head of the fillister head cap screw is cylindrical.

Look now at Box D. Notice that the underside of the head, called the bearing surface, is flat. We can say that the bearing surface forms a right angle with the body.

Look at Box E. Recall that the threads of the fillister head cap screw can either go part way up the body or all the way up the body to the head.

Now look at Box F. Here we can see that the fillister head cap screw can be long or short, wide or narrow. It can be made of black steel, bright steel, aluminum, bronze, copper or brass, and, therefore, can be different colors. However, it will always have:

1. a cylindrical head that is slotted and rounded on top,
2. a bearing surface on the underside of the head that forms a right angle with the body,
3. threads that go part way or all the way up to the head, and
4. a flat base.

Turn now to Box G. Can you tell that numbers 1 and 2 are somewhat the same? Notice that they both are threaded the full length of the body; they both have slots in the head. Number 1 has a bearing surface that forms a right angle with the body, but number 2 has a bearing surface that is not at right angles with the body, nor is the head on number 2 dome-shaped or slightly rounded. Because of this number 2 is not a fillister head cap screw.

Now look at Box H. Both screws look much the same: they both have flat bases; they are both threaded for the full length of the body; the bearing surface of each is at right angles to the body. However, number 3 does not have a cylindrical head nor is the head slotted. So number 3 cannot be a fillister head cap screw.

Glance at Box I. These two screws are also somewhat the same. Observe that: they both have flat bases; they both have threaded parts and unthreaded parts of the body; they both have a bearing surface that forms a right angle with the body; they both have slots in the heads; the tops of both heads are rounded. However, the head of number 6 is not cylindrical like a drum, so number 6 cannot be a fillister head cap screw.

The screws shown in Box K all have:

1. a flat base,
2. threads which go part way or all the way up the body,
3. a bearing surface which forms a right angle with the body, and
4. a cylindrical or drum-shaped head which is slightly rounded on top and slotted.

Each example in Box K has all of the parts that a fillister head cap screw should have.

In Box L you can see different kinds of bolts and screws. With your pencil, encircle all of the ones you think are fillister head cap screws. Then on the line below the box, write the letters of all those you encircled. (45 second pause) See if you have written these letters: B, D & G. If you have all three listed and no others, you get a perfect score. If you missed some or put some down that are not fillister head cap screws, look over the ones you missed and see if you can tell why they are not fillister head cap screws.

Nontechnical Narrative for the
Fillister Head Cap Screw

Look now at Box A. Point to the screw that is shown there. This screw is called a fillister head cap screw, a fillister head cap screw.

Look at Box B. Notice that the top of the head of the fillister head cap screw is rounded just a little.

Now look down to Box C. Notice that the sides of the head look like a wall. The sides of the head are straight, which makes the head look like a loaf of bread with a bite taken out of the middle.

Look across to Box D. The head of the fillister head cap screw is wider than the body, so it sticks over the edge of the body.

Turn the page, please, and look at Box E. Here you see two fillister head cap screws. Notice that the threads on the fillister head cap screw can go part way up the body or they can go all the way up the body. It does not matter whether the threads go part way or all the way up the body, it is still called a fillister head cap screw if it has the box-like head that is rounded a little on top and has a slot.

Look down at Box F, please. Here you see four fillister head cap screws. You can see that the threads go only part way up to head on some and on others that the threads go all the way up to the head. It doesn't matter, it's still a fillister head cap screw. Notice that the bottom of the fillister head cap screw is always flat, that the box-like head is slightly rounded on top and has a slot in the center.

Turn the page please, and look at Box G. In Box G are two screws. Number 1 is a fillister head cap screw, number 2 is not. It does not have a rounded head, and the sides of the head are not flat.

Look at Box H. In Box H there are two screws. Number 3 is not a fillister head cap screw, however, because it does not have a rounded head with a slot in the center. Number 4 does have these things, so it is called a fillister head cap screw.

Look down at Box I. Number 5 is a fillister head cap screw, number 6 is not. The sides of the head of number 6 are not flat.

Turn the page, please, and look at Box J. In Box J are three different kinds of screws. None of the screws is a fillister head cap screw, however. Number 1 does not have a slot; number 2 does not have a box-shaped head with straight sides, and the head of number 3 does not have straight sides.

Look down at Box K. All of the screws shown in Box K are fillister head cap screws. Once again, notice that the threads can go all the way up to the top or only part way up to the top. Plus, each of them has:

1. a flat bottom,
2. threads going either part way up or all the way up to the head,
3. a head that is wider than the body, and
4. a box-shaped head that has flat sides and is slightly rounded on top with a slot in the center.

Turn the page, please, and look at Box L. In Box L are several kinds of screws and bolts. Will you please circle with your pencil all of the fillister head cap screws and then write the letters of the ones you circled at the bottom of the page. Once again, circle only the fillister head cap screws. Did you circle B, G, and D. If you did, you circled all the right ones. Congratulations! If you circled any others, look at them carefully to see how they differ from B, G, and D. Letter E, for example, looks almost the same but it does not have a box-shaped head with straight sides. When you are ready, turn the page please, and look at Box A where you will see a hexagon socket set screw.

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